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FARMERS' BULLETIN 331.

FORAGE CROPS FOR HOGS IN KANSAS AND OKLAHOMA.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Washington, D. C., May 20, 1908.

Sir: In December, 1907, there was issued as Part IV of Bulletin 111 in the series of this Bureau the accompanying paper on Forage Crops for Hogs in Kansas and Oklahoma. The practical character of this paper and the large demand for copies lead me to recommend that it be reissued as a Farmers' Bulletin; and, with this end in view, it has been revised.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary.

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FORAGE CROPS FOR HOGS IN KANSAS AND OKLAHOMA.

INTRODUCTION.

Farmers are more and more realizing that pasture is necessary for the most economical production of pork. Those who are raising hogs and putting them on the market with the least cost have their entire farms fenced " hog-tight." This enables them to give the hogs the range of the meadows and fields when the crops have been harvested. Much that would otherwise be lost is thus saved by the hogs, for they are among the best gleaners of waste grain, weed seeds, and insects in the fields.

More hog pastures are fenced each year, more experimenting is done, and there is more inquiry as to the best crops for pasture. These questions can not be answered intelligently without a knowledge of the conditions of soil and climate, the market, and the adaptability of crops to different sections of the country.

The Office of Farm Management Investigations has undertaken to ascertain by a study of farm practice: (1) What crops have been found best for pasture for hogs in different localities; (2) the season during which these crops are available; (3) the number of stock they will pasture to the acre; (4) the value of this pasture in connection with other feeds; (5) the quantity of grain necessary to produce a given amount of pork on different pastures; and (6) the cost of producing pork.

While only a small beginning has been made, the demand for such knowledge and its importance to the swine industry of the country has prompted the publishing of this information for each locality as it is obtained.

Although the investigation has not as yet extended beyond a single region, embracing portions of Kansas and Oklahoma, it is believed that the information secured and the suggestions made will be of considerable value to hog raisers in other regions, especially in those areas which have similar soil and climatic conditions.

CROPS USED IN KANSAS AND OKLAHOMA.

During the past summer (1907) about 150 of the most successful swine growers and pork producers of Kansas and Oklahoma were interviewed on the subject of the crops used for feed. In southern Oklahoma along the river valleys and in northern Oklahoma and southern Kansas the farmers are favored with a soil and climate that make it possible to produce pork very cheaply. The mildness of the climate makes it unnecessary to build as expensive shelters for hogs in winter as are required farther north, and the short open winters make it possible to furnish pasture during a greater portion of the year, thus lessening the amount of grain which it is necessary to feed. The main pasture crops for hogs in this region are alfalfa, wheat, oats, and rye, ranking in importance in the order named.

ALFALFA.

It is the testimony of 95 per cent of the farmers interviewed in this region that there is no better forage crop for hogs than alfalfa, where it can be grown successfully.

Alfalfa Pastures.

Amount of pasturage.—As to the amount of pasturage or the number of hogs alfalfa will carry per acre without injury to the crop, the estimates given by farmers vary considerably, depending on the kind of soil, the fertility of the land, and the size of the hogs pastured. The following, however, is a safe average estimate as given by conservative men who have had much experience. River valley and creek bottom land well set in alfalfa will carry from 15 to 20 head per acre of 50 to 125 pound hogs. Upland of fair average fertility will support from 8 to 10 head of the same kind of hogs. There are fields that have supported 25 head per acre all through the season for a number of years and are still in good condition, and there are other fields that will not furnish pasture for more than 5 head per acre; but these are extremes. When a field is used only for pasture it is better to divide it into several lots and move the hogs from one to the other as occasion requires.

Causes of failure.—Those who have failed with it as pasture owe their failure to two causes:

The first is that the alfalfa has been pastured before it has become well rooted. Young alfalfa is too tender a plant to stand severe treatment except under very favorable circumstances. There are a few farmers who have pastured it the same year it was sown and the alfalfa has survived; but this was on rich heavy loam soil, usually creek bottom or river valley land with water not far below the surface, and the season was very favorable. Ordinarily alfalfa should not be pastured until the second year, and better still not until the third year if it is desired to keep the field as permanent pasture.

The second cause of failure with alfalfa is heavy pasturing and lack of judgment in pasturing in unfavorable seasons. A good many farmers have sown a small piece of alfalfa, and then, because it has grown rapidly and all kinds of stock are fond of it, they have turned all the stock on the farm on it and have wondered why their alfalfa was killed out. Others pasture regardless of whether the ground is muddy or whether the season is dry and hot. In either case heavy pasturing is very likely to cause the alfalfa to be killed out.

Length of pasture season.—The length of the season during which this pasture is furnished also varies. Alfalfa is ready for pasture on the average from the middle of April in southern Oklahoma to the middle of May in northern Kansas. It is not best to pasture earlier, as the young alfalfa has not the start it should have for heavy pasturing, nor has it the substance in the plant. When not pastured too early, it will furnish feed at the rate mentioned during nearly the whole season until October in the northern part and November in the southern part of the section referred to. In some years the pasture season will continue a month later in the autumn, owing to the rainfall and the lateness of cool weather. In some seasons, if the summer is unusually dry and hot, the pasture will become short; but usually pasture for the number of hogs mentioned can be depended on for about seven months of the year at the southern limit of the territory named and for about five months at the northern limit. This rule will apply to other sections of the country having the same climatic conditions as Oklahoma and Kansas.

While many farmers pasture alfalfa fields to their full capacity, in some sections, especially in northern Kansas, it is customary to run about half as many hogs as the alfalfa fields will support. This practice permits the cutting of the usual number of crops of hay, though the yield of hay is, of course, reduced.

Food character of alfalfa.—Alfalfa not only furnishes a great amount of pasture, but it is of a character that goes to make bone and muscle. It belongs to the leguminous family of plants, as do the clovers, the cowpea, the field pea, the soy bean, and the vetches, and, while it is furnishing this valuable food, it is adding fertility to the land. Either alfalfa pasture or alfalfa hay, with corn, forms very nearly a balanced ration for animals; and, while it is better to have a grain ration fed with it to hogs as well as other animals, a healthier thriftier hog can be raised on alfalfa alone than on corn alone. Many instances are found where hogs have been raised on alfalfa alone. One Oklahoma farmer marketed in December, 1905, 61 head of spring pigs eight months old that averaged 171 pounds, which had run from the time they were little pigs with their mothers on 15 acres of alfalfa without any grain. They sold on the market for 5½ cents a pound. This made the cash value of the alfalfa pasture about $38.35 per acre. As will be seen, this is light pasturing, as there were only about 4 pigs per acre besides the brood sows.

Feeding practices and actual results.—As already stated, it is much better economy to furnish a grain ration with the pasture, as it results in better gains and a better product. One man estimates that it takes from one-half to one-third less corn on alfalfa pasture than on a straight grain ration to make a hog ready for market. Many let the hogs run on alfalfa until about six months old, by which time they reach a weight of 75 to 125 pounds, feeding just a little grain; then they feed heavily for about two months and sell the hogs at eight months old weighing 200 to 225 pounds. One farmer, who raises about a thousand hogs a year and who in one year sold $11,200 worth of hogs, makes a practice of raising his hogs on alfalfa pasture until about eight months old, feeding one ear of corn per head daily. He then feeds heavily on corn for a month or two and sells at an average weight of 200 to 225 pounds. Another man feeds all the corn and slop the pigs will clean up, all the while running them on alfalfa pasture, and sells at six to eight months old at weights of 250 to 300 pounds. Another, who raises about a thousand head a year, feeds all the corn the pigs will eat, beginning shortly after weaning and continuing until the hogs are sold at ten to eleven months old, averaging about 275 pounds.

Still another farmer, from weaning time (two months old) until eight months old, feeds the pigs nothing but dry corn on alfalfa pasture, averaging about one-half gallon of corn (3½ pounds) a day per head. At the end of eight months he sells at an average weight of 250 pounds. The quantity of corn fed is about 11¼ bushels per head. Figuring at the average price of corn in this locality, 35 cents, and the price received for pork, 5½ cents, the following results show the cost of growing pork on this farm and the value of alfalfa pasture:

Value of 250-pound hog, at 5½ cents	$13.75
Value of pig at weaning, 50 pounds, at 5½ cents	2.75
Gain from pasture and grain	11.00
Cost of 11¼ bushels of corn, at 35 cents	3.93
Value of pasture per head pastured	7.07

Now, compare these results with those of a man who had to depend on other pasture crops than alfalfa. He estimates that it will take 15 bushels of corn on wheat, oats, and rye pasture to raise and fatten a hog so it will weigh 240 pounds at nine months old, besides the pasture and slop. At the price of corn mentioned, 35 cents a bushel, and with hogs at 5½ cents a pound, note the cost of producing pork on this farm:

Value of 240-pound hog, at 5½ cents	$13.20
Value of pig at weaning, 50 pounds, at 5½ cents	2.75
Gain from pasture and grain	10.45
Cost of 15 bushels of corn, at 35 cents	5.25
Value of pasture per head pastured	5.20

The pasture on this farm will not support more than half as many head per acre as alfalfa pasture. Its value is only $5.20 per head, against $7.07 per head for alfalfa pasture on the other farm.

The experiences of these men are sufficient to show the value of alfalfa pasture alone, its greater value when grain is fed in connection, and that it is an important factor in economic pork production.

Alfalfa Hay.

While alfalfa pasture has been found to be very valuable for hogs, the hay as a part ration for winter is scarcely less important. Throughout the region referred to the farmers are feeding the hay to hogs in winter. The hay has been found to be especially valuable for brood sows before farrowing. Where it is fed during the winter only a small ration of grain is necessary to keep the sows in good flesh and in healthy condition. Sows thus fed also farrow good litters of strong, healthy pigs.

Feeding methods.—Many feed the hay by throwing it on the ground in forkfuls; others have made low racks in which the hay is placed, where the hogs can feed like cattle or sheep. The hay is usually fed dry. The leaves are more readily eaten by the hogs than the stems, and they contain more of the nutritive value of the plant. For these reasons some farmers save the last cutting of hay for the hogs because it is more relished. It is eaten up cleaner, as the stems are not so woody. Sometimes the hay is cut up fine, wet, and mixed with other feed, and sometimes it is fed ground, as there are now alfalfa mills scattered throughout the alfalfa regions. But it is very doubtful whether this extra expense will pay, unless it be for a ration for young pigs.

Experiences of farmers.—To avoid the expense of cutting or grinding, some farmers in order to get the hay all eaten have soaked it in water and fed it. This has proved very satisfactory where tried. One Oklahoma farmer carried his hogs through a winter by feeding them alfalfa leaves soaked in hot water for one day and the next day shorts mixed with the pulp and water. He feeds much alfalfa hay to his hogs and is very successful with them. He puts the last cutting in shock as soon as wilted, and thus cures it without bleaching and feeds it to his hogs. Another farmer carried his entire herd of hogs through the winter by feeding them the pulp of alfalfa hay after soaking it in water over night. He also gave them the water to drink. This was all the feed they had during the winter, and they were in good flesh in the spring, with smooth, glossy coats of hair. A Kansas farmer was feeding a bunch of 50 fall pigs on corn. During the winter they got "off feed" and were not thrifty. He reduced the corn and gave a ration of two-thirds chopped alfalfa hay and one-third corn meal, the two soaked together. The hogs began to do better, and a little later he changed the ration to one-third alfalfa and two-thirds corn. The results were very satisfactory, and the cost of feed was reduced from $15 a month on corn to $9 a month on alfalfa and corn. So alfalfa hay, as well as pasture, has a very important use on a hog farm.

WHEAT.

Pasturing winter wheat.—In northern Oklahoma and southern Kansas winter wheat is a staple crop. It is generally sown from the middle of September to the first of October. The amount of seed used is from 1¼ to 1½ bushels per acre. If the ground has been well prepared and the fall is not too dry, this will have made a good growth by the time alfalfa pasture begins to fail, along in November. The season here usually remains open until Christmas, so that six weeks of very good pasture are furnished. Some winters are so open that the wheat remains green most of the winter and stock find pasture all winter. The spring opens up by the last of February, and the wheat gets green again in March. By judicious pasturing—not pasturing too heavily or when the ground is muddy—much green feed may be had without injury to the wheat. The farmers here have taken advantage of this, and, where they have their wheat fields fenced hog-tight, turn the hogs from the alfalfa field to the wheat field in November and leave them there during the winter unless the wheat gets too short or the ground becomes muddy. The hogs remain in the wheat until April and do well with very little grain. At this time they can go back to the alfalfa field again. Thus, green pasture is furnished the year round.

Where this is possible two litters a year of 200-pound hogs can be raised with profit, and pork is thus produced very cheaply.

Difficulties.—One farmer of large experience thinks it is dangerous to pasture pigs at about weaning time on wheat. He has lost twice, he thinks, from that cause. The last time he saved only 15 out of 45 head. He claims that wheat is too fibrous and collects in balls in a pig's stomach and intestines, causing inflammation, from which the pig dies. It is claimed by some farmers that wheat is injurious to hogs just as it begins to shoot in spring. More information is needed on this point. The usual practice is to remove the hogs from wheat in early spring and put them on alfalfa or other summer pasture, so that experience with wheat pasture later in the season is limited.

Value as a forage crop.—Wheat will not carry as many hogs to the acre as alfalfa. The usual number is about 6 head per acre, though some farmers claim that the maximum is about 10. One man claims that hogs are excellent animals for pasturing on wheat, not trampling it out as cattle or horses do.

The value of wheat as pasture lies chiefly in the fact that it furnishes green feed for the hogs at a season of the year when it is very much needed, especially by young and growing hogs. By having pasture at this season there is a great saving of grain, very little being needed. It also enables fall pigs farrowed in September to be carried through the winter in good condition, thrifty and well grown, so that by giving corn in the spring they can be sent to market by June nearly as cheaply as the March pig can be shipped by December. Quite frequently, where hogs have been grown on pasture, they will, when put on a heavy feed of corn, make a gain of 12 to 15 pounds for every bushel fed.

OATS.

In the same region where wheat is used for pasture, oats are also used for spring pasture and are highly spoken of by all who have used them. Some claim that hogs will do better on oats than on wheat. The hogs like them better and will eat them as long as they grow, while they do not like wheat when it begins to head. In this region many sow oats in March to furnish spring pasture for the hogs when they come off the wheat and before the alfalfa is ready to pasture. Sometimes oats are sown with rape at this time for the same purpose and to give variety to the pasture. Oats will furnish pasture at about the same rate as wheat.

The great value of oats is due to the fact that they furnish succulent feed at a season when it is much needed. They are also greatly relished by hogs. Oats are particularly valuable as pasture for sows and young pigs, many farmers sowing them for this purpose. One farmer claims that he is less troubled with scours in pigs on oat pasture than on alfalfa.

RYE.

Rye is not so generally grown for a pasture crop in Oklahoma and Kansas as the crops just discussed. Many farmers, however, use rye to make a part of the pasture crop for their hogs, and its value can not be denied.

Rye is sown from September 1 to the middle of October. The early seeding is best, as it comes on early and gets well established before cold weather, and will thus make better fall and winter pasture. Rye is an excellent pasture for late fall, winter, and early spring. If not pastured too heavily in the spring it will head out and make a very good yield of grain. The grain is an excellent ration to feed with corn to pigs and growing hogs or to grind and mix in slop for sows with pigs.

The amount of pasture furnished by rye is about three-fourths that furnished by alfalfa, its carrying capacity being estimated at 6 to 12 hogs per acre. One man reports having pastured 50 head of hogs on 5 acres during fall, winter, and spring, then harvesting 20 bushels of grain per acre. In the southern part of this region rye would be an excellent cover crop for the soil during the winter. Besides furnishing pasture, it could be turned under as a green manure to add humus to the soil.

LESS IMPORTANT FORAGE CROPS.

While alfalfa, wheat, oats, and rye are the principal forage crops, there are others that are used to some extent. Among these are clover, rape, sorghum, cowpeas, soy beans, artichokes, and grasses.

Clovers.

The clovers are not generally used in the territory discussed. Among those most used for pasture crops are red clover and white clover. These are good in the latitude of central Kansas and farther north, but south of this the clovers do not do so well. Red clover and white clover are in more general use in the older sections of the country. They are both excellent forage crops for hogs.

Red clover.—Red clover comes in well in the rotation of crops; it fertilizes the land and furnishes both pasture and hay. It is often sown with oats or barley in the spring, or later in corn after the last cultivation. It does very well with corn where there is sufficient rainfall, but in the drier regions this plan is not to be recommended. The first fall it is used for pasture; the second season it is used as a pasture and hay crop. It will furnish pasture for about 10 head of hogs per acre during the first half of the season and half that many the last half, provided the soil is fairly good and the season not too dry. The hay is excellent for hogs, especially for brood sows in winter, but does not equal alfalfa hay.

White clover.—White clover is better used in permanent pasture with some of the grasses, as Kentucky bluegrass. It will not furnish as much pasture as red clover, but is especially good while in bloom during May and June. It does better on moist ground than red clover and will do very well on some poor soils. It is not recommended to sow alone nor for hay, although the dry hay contains more than 14 per cent of crude protein.

Alsike clover.—Alsike clover is better in some regions than red clover, especially on low, moist ground. In some localities farther north it does better and is a more certain crop. It will supply about as much pasture as red clover, is sown at the same time, and furnishes pasture for the same period. As a hay crop it will not yield as much, but it is a little better than red clover, as it does not have as woody a stem.

Crimson clover.—Crimson clover has not succeeded well in the past in this region, but is to be recommended for further trial as a pasture crop. Along the Atlantic coast, the only region where it is largely and successfully grown, it has been found that the hairs of the blossoms are likely to gather in dense balls in the stomach and intestines of animals, especially the horse, and cause death. For this reason it should not be cut for a hay crop after the flowers mature. It is an excellent winter pasture crop for swine, however, and will furnish more pasture than red clover. It is a winter annual, and should be sown in August or September.

The chief value of crimson clover is that it acts as an excellent cover crop for soil during the winter months and prevents the soil from washing or leaching. It also furnishes in southern regions excellent winter and early spring pasture for hogs.

Rape.

Methods of culture.—Rape is usually sown in early spring—in March or early in April—in Oklahoma and furnishes pasture by May. The Dwarf Essex variety is used. It is sown either broadcast, at about 4 pounds of seed per acre, or else in drills 30 to 32 inches apart, using 3 pounds per acre. Drilling is the best method, as this permits of cultivation. The plants grow more rapidly and make pasture sooner. When sown in drills, the hogs will not break down and destroy so much of the crop.

Value as a forage crop.—Early-sown rape will furnish pasture from May until August. If rape is not grazed too closely in the spring and the stalk is not eaten off, it will grow up and make fall pasture. A good growth of rape will supply pasture for about 15 or 20 hogs to the acre. One man claims that it will take 25 head to pasture it down. Its value as a forage crop is shown in the experiments of the Wisconsin Agricultural Experiment Station, where it was proved to have a feeding value per acre, when combined with a ration of corn and shorts, equivalent to 2,436 pounds of grain and a money value of $19.49 per acre. The seed can be bought usually for 8 cents a pound, and 3 to 5 pounds an acre is all that is needed. Rape should not be pastured until it is a foot high.

Difficulties.—It is often difficult to get hogs to eat rape at first if they have not been accustomed to it. For this reason it is not grown by some. Considerable complaint is made that rape causes sores and scabs on the hogs. Sometimes the skin has the appearance of being blistered. This is especially true of white hogs. This difficulty can be remedied somewhat by removing the hogs to other pasture crops for part of the time and applying a mixture of sulphur and lard to the sores.

As one of the annual forage crops rape is valuable on account of the cheapness of the pasture, the quantity of feed furnished, the general thriftiness of the hogs on the pasture, and because it adds variety to the ration and is available at a time when other pastures may be short.

Sorghum.

Sorghum is used quite extensively in the drier upland regions for summer pasture. It is valuable on account of the great amount of feed furnished, pasturing from 20 to 30 head of hogs per acre. It comes in as a summer pasture when other pastures are short on account of hot dry weather. It is sown in May and furnishes pasture during July, August, and September, or even later.

Sorghum is less palatable and nutritious than many other forage crops adapted to this region. For this reason many do not like it as a pasture crop. Hogs do not thrive as well on it as on alfalfa and require more grain to keep them growing nicely.

The special value of sorghum lies in the fact that it furnishes a great abundance of pasture in dry hot weather when alfalfa makes little growth. After it is well started, say 2 feet high, it will furnish fairly good pasture for 30 hogs to the acre for a few weeks, and a good crop will carry 25 head of 100-pound pigs nearly all summer.

Cowpeas.

Cowpeas are just beginning to be recognized in this section as having great feeding and fertilizing value. They do much toward restoring the fertility of the soil, and some farmers are making use of the vines as a forage crop for their hogs. Wherever they have been tried the farmers are enthusiastic in their praise of them. Not enough data have been obtained on pasturing to be able to say how many head of hogs cowpeas will support per acre; but in a comparison of their feeding value for hogs with that of corn the results obtained by the South Carolina Experiment Station show their importance. In this test 6.02 pounds of corn and 4.91 pounds of cowpeas were necessary to produce a pound of pork. One farmer in Oklahoma reported that his hogs preferred the cowpea hay to alfalfa hay. All kinds of stock are fond of the hay and do well on it.

Cowpeas furnish a food on which hogs make good gains. The plants will make a good growth on rather poor soil and furnish feed during late summer and fall when other green crops may be short. They also bring the soil into a more productive state, the same as clover or alfalfa.

If cowpeas are planted in May they will make late summer pasture. The best pasture is obtained after the peas are formed and well grown, as the peas are very nutritious and cause the hogs to gain in flesh rapidly.

Canadian Field Peas.

In this same latitude in the higher altitudes, as in the San Luis Valley in southern Colorado, where it is too cold for corn, the farmers have found the Canadian field pea a very profitable crop for forage both for sheep and hogs. A large acreage of these peas is put in each year, the peas being sometimes sown alone, but more frequently with oats or barley. The seeding is done in April or early in May, and the crop can be pastured by midsummer. The best season for pasturing, however, is later, when the peas have formed, the stock being allowed to harvest the crop. Hogs make a very thorough harvesting, cleaning up the peas and the vines quite thoroughly. What vines are left on the ground, together with the manure, enrich the soil and add more humus to it. In addition to this the labor of harvesting is saved. Some fields, of course, are harvested for hay and make excellent winter forage for cattle, horses, and sheep. The hogs raised in this valley receive no corn. They go on the market as bacon hogs, and top the market in competition with corn-fed hogs. These hogs usually get no farther than Pueblo, Leadville, Silverton, and adjoining towns. The Pueblo packers have been using them for a number of years and speak very highly of them. Thus, the field pea has made the hog industry profitable outside of the corn belt.

Soy Beans.

The soy bean is used but little as a forage crop by farmers in this section, and the value of this crop is but little appreciated. Soy beans can be planted on a field from which a small grain crop has been removed, and some varieties will make an excellent growth of forage and even mature seed. They will thus furnish pasture for hogs during the latter part of August and September, and the green and ripening beans when harvested by the hogs in this way make an excellent feed. The beans when fed in a ration consisting of one part beans and three to five parts of corn or Kafir corn, as shown by the Kansas Agricultural Experiment Station, make a very profitable ration for fattening hogs. The saving in the amount of feed necessary to make a gain of 100 pounds is from 13.2 to 37.5 per cent and the increase in gain is from 14.6 to 96.4 per cent. Also, in a feeding test at the Indiana Agricultural Experiment Station, where soy beans, middlings, and tankage were used as rations with corn, the soy beans proved to be the most valuable adjunct used. As compared to corn fed alone, hogs that received one-third soy beans [illegible] thirds corn made two and one-fifth times as much gain in the same length of time. The cost per 100 pounds of gain where corn was fed alone was $5.01 against $3.59 where one-third soy beans and two-thirds corn was fed. Hogs so fed look thrifty, have a good appetite, fatten rapidly, and have glossy hair like animals fed oil meal.

The great value of the soy bean is its power to withstand excessive drought, like Kafir corn, and it will also withstand much wet weather. It is not attacked by chinch bugs and in addition to its great feeding value makes an excellent second crop following wheat or oats to build up run-down or thin soil. Protein is very necessary in a ration for building bone and muscle, as all feeders are coming to know, and the soy bean is exceptionally rich in this. It even stands ahead of alfalfa in this respect.

Grasses.

The grasses are not so good for hog pasture as the crops previously mentioned, but they are used to some extent. Those most commonly grown are Kentucky bluegrass, English bluegrass or meadow fescue, Bermuda grass, and the native wild grasses.

Kentucky bluegrass is used through Kansas and southern Nebraska. South of Kansas in Oklahoma Bermuda grass is used.

As an example of the value of English bluegrass, the experience of one farmer in northern Oklahoma may be cited. He uses only English bluegrass and wild grass as pasture. On 12 acres of the bluegrass sown the fall before he pastured 150 head of stock hogs all the spring until about the middle of May. The hogs were then taken off and the grass allowed to go to seed. This farmer states that he harvested a crop of seed larger than the ordinary crop.

Bermuda grass is not much used as a pasture for hogs, but should be grown more in regions to which it is adapted. It is relatively rich in protein, is not easily killed out by pasturing, and withstands drought well. It is often used as a soil binder, and might well be used for hog pasture. Many hilly farms that are now washing badly could be put in Bermuda grass and pastured to stock, thus saving the land and building up the soil. Some farmers are beginning to make use of this grass and are fencing it for hog pasture. It withstands heavy grazing, rooting, and trampling.

Some farmers have fenced in the prairie grass and are now grazing their hogs on it. While it does not have a very high feeding value, hogs will do very well on it with grain. One man claims that prairie grass will make hogs hold their own at the rate of 6 head per acre.

Root Crops.

The root crops most used in this territory are potatoes, artichokes, peanuts, and sugar beets.

Artichokes.—Artichokes are a very good root crop to use for hogs. They can be planted in the spring in the same way as potatoes and cultivated the same. In the fall the hogs can be turned in to harvest them. They thus furnish a good late fall and winter food, especially for brood sows and shoats. One farmer claims that 1 acre will keep from 20 to 30 head in fine condition from October till spring. Their use reduces considerably the amount of corn that must be fed. None of the tubers need be dug except for seed; the hogs will dig the rest. Early in the fall hogs do not eat artichokes readily. In winter and spring they eat them greedily.

Artichokes have a tendency to become a pest on cultivated land; and, if planted continuously on the same land, they become diseased. They may be grown very successfully, however, in a pasture crop rotation for hogs. As the acreage needed is not large, they can be planted on a part of a field in March or April, the rest of the field being sown to rape. In August the part sown to rape can be reseeded to rape for fall pasture. The next spring oats can be sown after the rape, and barley after the artichokes. The crop may be pastured continuously if needed, or later mowed for hay. In August, after this crop is removed, rye and clover may be sown. This will furnish pasture for the ensuing fall and for the following year. This makes a three-year rotation of pasture crops that fit in very well with each other. Preparing the land in July and August for the following crop of rye and clover effectually eradicates the artichokes.

The Oregon Agricultural Experiment Station made a test to determine the feeding value of artichokes with grain for hogs. The result of the test showed that where they were fed there was a saving of nearly 2 pounds of grain for every pound of gain in live weight. Besides, the hogs were healthy and vigorous all the time.

The artichoke is superior to the common beets and turnips for hogs, about equal to potatoes, and richer in protein than sweet potatoes.

Peanuts.—Peanuts are but little used in this region, but farther south and east they are used extensively. One man estimates that when pork is 4 cents a pound, peanuts return $10 per acre when harvested by hogs.

The Alabama Agricultural Experiment Station made investigations as to the relative value of peanuts, chufas, cowpeas, rape, sorghum, and sweet potatoes as pasture crops for hogs. The amount of grain required with peanuts to make 1 pound of gain was 1.77 pounds; with chufas, 2.3 pounds; with rape, 2.68 pounds; with cowpeas, 3.07 pounds; with sweet potatoes, 3.13 pounds, and with sorghum, 3.7 pounds. Five Tamworth hogs in twenty days on Spanish peanuts gained 2.29 pounds a day each.

Peanuts can be very profitably grown in many sections in the latitude of Oklahoma and Kansas. This crop will do better on a sandy loam than on a heavy clay soil, and will make a fair crop on thin soil where corn will not yield well. They are a very good crop to raise, both for pasture and for hay; stock of all kinds are very fond of the hay. When the nuts are left on, it is richer in protein than alfalfa hay. The best variety to grow, both for hay and pasture for hogs, is the Spanish peanut. It is a small-sized nut and grows in great clusters close around the taproot of the plant. The Spanish nut is not so particular in soil requirements as the larger varieties and is easier harvested on account of growing in clusters.

It is claimed that peanuts can be grown in dry regions where corn will not succeed. This, if true, is important in the southern plains region. Peanuts can be made to take the place of corn in fattening hogs, although the peanut-fed hog makes softer lard and the quality of the meat is not so good, especially in the bacon hog. But as an adjunct to corn the peanut is an excellent forage crop. It is claimed that the northern-grown nut is better flavored and less oily than that grown in the South.

The peanut can be planted the last of April or the first of May in the latitude of the regions discussed in these pages and is ready to turn the hogs on by the last of August.

Sugar beets.—In Colorado, in the sugar-beet district, hogs have been fed quite extensively on beets in the winter. Beets do not prove satisfactory when fed alone, but are used to some extent as part ration with grain. One farmer states that he saves a good supply each year to feed in the winter to his hogs to keep them in a healthy condition.

In a feeding test at the Colorado Agricultural Experiment Station sugar beets proved to be wholly unsatisfactory when fed with grain. The cost per hundred pounds of gain of hogs fed beets and barley was $6.01; of hogs fed beets and corn $7.22, the latter being higher than any other ration fed.

Pumpkins.

Pumpkins are an excellent feed for keeping hogs in a healthy condition. Many farmers claim that the seeds of pumpkins will prevent worms in pigs and shoats and that a ration of pumpkins fed with grain will keep hogs thrifty and give them a good appetite. A good many wagonloads can be grown on an acre of rich land. Stumpy land or low moist land will grow good pumpkins.

PASTURE CROPS FOR DIFFERENT SEASONS.

is not the purpose of this bulletin to discuss the rotation of crops
its importance on the farm, but the aim is to briefly mention
'orage crops that are adapted for hogs each month of the year
is region and to explain how they can be made to overlap each
', so that green pasture can be provided for each month in the
ıern part of the territory discussed and for the greater part of
'ear in the northern part. Hog raisers know that during some
hs of the year there is an abundance of pasture, while during
s there is very little if any, at which times other feeds must
esorted to that will supply the deficiency. The extra feed re-
ed is expensive and cuts down the margin of profit in pork
uction.

will not be practicable to name the crop that is best adapted to
r locality for the different seasons, as each farmer must know his
ınd conditions and adapt his crops to those conditions. The fol-
ıg table will show the crops that may be ready for pasture in the
hs specified and the possible area of pasture provided, but the
e of one or more crops from the list must be left to the farmer
elf.

that may be available for pasturing hogs during the different months of the year, with the number of head an acre will support.[a]

sture during—	State.	Crops that may be used.	Time of sowing.	Number of hogs that can be pastured per acre.
nd May	Oklahoma	Alfalfa	A previous year	8-16
		Rye	Preceding fall	6-10
		Oats	March 1	6-10
		Rape	do	15-20
	Kansas	Alfalfa	A previous year	8-16
		Rye	Preceding fall	6-10
		Clover	do	6-10
		Oats	Last of March	6-10
		Kentucky bluegrass.		8-10
		English bluegrass	Preceding fall	8-12
ıd July	Oklahoma	Spring rye	March 1	6-10
		Late oats	April 15	6-10
		Sorghum	March 1 to April 1	20-30
		Alfalfa	A previous year	8-16
		Potatoes	March	(Unknown.)
	Kansas	Rape	March 1 to April 15	15-20
		Spring rye	April 1 to 15	6-10
		Late oats	April 15 to May 1	6-10
		Sorghum	April 1	20-30
		Alfalfa	A previous year	8-16
		Prairie grass		5
and September	Oklahoma	Sorghum	April	20-30
		Cowpeas	May	10
		Soy beans	do	13
		Peanuts	April	8-10
		Alfalfa	A previous year	5-10
	Kansas	Sorghum	May 1	20-30
		Cowpeas	do	10
		Soy beans	do	10
		Peanuts	do	8-10
		Potatoes	April 1	(Unknown.)
		Alfalfa	A previous year	5-10

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e number of hogs that can be pastured per acre, it must be remembered, depends fertility of the soil, on the season, and on the size of the hogs. This estimate is on the same figures as were secured on alfalfa pasture; i. e., hogs that weigh from 125 pounds per head.

h corn is taken in. This pasturing is begun at the same time that ı is usually cut up green and fed to hogs, i. e., when it is in the sting-ear stage. This plan of feeding is kept up until the re- nder of the corn is all husked from the field. Then the hogs are ned in to clean up the waste corn in the field. Last summer cow- s were drilled in the corn when it was cultivated the last time. ese furnished much valuable feed in addition to the corn.

n April this man had 20 head of fall pigs averaging about 125 ınds. These shoats had had no feed except wheat and alfalfa ture and the waste grain they gathered from the field, except a le corn that was thrown to them each day in the late winter and ly spring. In April they were put on ground corn for thirty days. ıring this time each ate an average of one-fourth bushel daily. At end of thirty days they averaged 225 pounds. This makes an erage gain of 3⅓ pounds per day, or a little more than 13 pounds of in for each bushel of corn fed. The market price of corn was 50 ıts a bushel. The hogs sold at $5.50 per hundred, thus bringing ⅓ cents a bushel for the corn fed.

This farmer raises two lots of pigs a year, farrowed in March and ptember, turning off fall pigs in the spring and spring pigs in the ll, selling at 6 to 8 months old. From March 15 to November 1, 06, he turned off $720.50 worth of hogs and had 22 head in the fat- ıing pens, all of his own raising and all grown and fattened on e products of his own farm.

EXPERIENCES OF FARMERS IN RAISING FALL PIGS.

Another farm in the same locality will serve as an illustration of ıat may be done with fall pigs in this section. Eighty head ran on e alfalfa and wheat fields of the farm during fall and winter. ıey gathered roughage and waste grain in the fields and were fed grain until 6 months old. At this age they averaged 135 pounds. ıey were then fed some corn on alfalfa pasture, the amount grad- lly increasing till the pigs were on full feed. Corn was fed for o months, during which time the pigs made an average gain of 14 unds for every bushel fed. They were sold at 8 months old, ighing 235 pounds each. The price of the corn was 45 cents a shel. This makes the cost of the corn fed $257.14, or $3.21 for each g. At the average price of hogs in this locality, 5½ cents, the rd averaged $12.92½ per head. Deducting the price of corn fed ıves $9.71 for each hog, to represent the value of the fall and winter sture, the farmer's labor, profits, etc.

Another farmer ran a bunch of September pigs on alfalfa and heat pastures until the following May, when they weighed 125 unds. They received in addition one ear of corn each twice a day.

At this time the corn was increased gradually until each hog was getting 10 ears twice a day, which this farmer claims is the maximum feed for young hogs. They were fed thus for six weeks, making in this time a gain of about 100 pounds a head, and consuming 10 bushels of corn each at a cost of $3.50 a head, or 3½ cents a pound for each pound of gain on corn. Allowing 4 bushels more as the quantity probably fed up to the fattening period at two ears a day, makes the cost for corn for each hog $4.90. To this adding $1.10 a head for pasture and slop (the cost of the slop fed is not known) brings the cost of each hog to $6.50 a head, or 2⅝ cents a pound. This allowed a good margin of profit at the ruling price of pork.

ALFALFA HAY FOR BROOD SOWS.

To show the importance of alfalfa hay in a system of feeding, the practice of the farmers around North Platte, Nebr., and elsewhere may be mentioned. The alfalfa hay is ground up fine or else fed whole with corn in the proportion of about 5 pounds of alfalfa to 1 pound of corn. This is fed to the brood sows during the winter, and they come through in excellent condition on very cheap feed. In many sections alfalfa hay is worth about $5 a ton on the farm. One ton of alfalfa and about 8 bushels of corn will keep three brood sows one hundred and thirty days, or nearly the whole winter. The hogs so kept farrow pigs that are remarkable for their vigor and size.

"HOGGING DOWN" CORN.

In these times of scarcity of labor and its high price many farmers are trying to reduce the labor on the farm. Some of the hog raisers have adopted the plan of harvesting the corn crop by turning the hogs into the cornfield and letting them gather it, or "hogging it down," as it is called.

A man in Ohio turned 122 spring pigs and older hogs (about equal numbers of each) into a 10-acre cornfield in September. The spring pigs averaged 82 pounds and the older hogs 156 pounds, and the total weight of all was 15,693 pounds. The corn would yield about 60 bushels an acre, and in it there were a good many pumpkins. The hogs had access also to a 5-acre clover field from which the seed had been removed. Water was hauled to them and they had the shade of the woods near by. In twenty-eight days the hogs had gained 6,522 pounds. At this time 57 head, averaging 245 pounds, were sold at $5.15 per hundred. The remainder were not sold, but the farmer was offered $5 per hundred for them. Counting the entire gain of 6,522 pounds at $5 would make $326.10, or $32.61 per acre for the field. This paid 52 cents a bushel for the corn which on the market was worth 40 cents. The whole herd made an average daily gain of 1.91 pounds per head.

A man in southern Kansas, who makes a practice of "hogging down" corn, uses a portable fence and fences off 5 to 10 acres at a time, taking in more as needed. He turns the hogs in the corn in August. On 12 acres of corn one year he fattened 50 head of hogs, the corn being estimated at about 600 bushels. Of the bunch 42 head were sold, averaging 240 pounds, netting $600. Allowing 100 pounds gain for each hog on the corn thus fed, the corn brought 41½ cents a bushel, without the expense of gathering.

A farmer in Oklahoma has been "hogging down" corn for a number of years. About 500 head of hogs are turned off this farm every year. By gathering and feeding corn beside that which was gathered by hogs, it was found that a bushel of corn "hogged down" will make as much pork as the same quantity husked and fed, while the expense of harvesting is saved; besides saving the labor of feeding the corn to the hogs, the field is also cleaned up better than a husked field.

An Iowa farmer began "hogging down" corn several years ago, using 20 acres the first year. He watched carefully the feeding of the hogs on this field and concluded that no more corn was wasted than would have been left in the field by the average husker. Since that time he has "hogged down" all his corn, thus saving the expense of husking. This man says the cost of husking for one year will make the fence around the field hog-tight, if there is already a wire fence for cattle. Husking 40 acres of corn yielding 40 bushels per acre, at 4 cents per bushel—it cost nearer 5 cents last season (1907)—amounts to $64. If the 40-acre field is square, this allows 20 cents a rod for the fence the first year. With a cattle fence already provided this will buy the wire to make it a good hog-tight fence.

Besides saving the expense of harvesting the corn, there are two other great objects to be attained by this method of harvesting corn: (1) The improvement of the land and (2) the health of the hogs. The farmer referred to says that in his first year's experience he snapped 20 acres of corn beside the field "hogged down." The next spring both fields were sown to small grain under the same conditions and with the same preparation. On the land where corn was "hogged down" the wheat made 5 and the oats 7 bushels more to the acre than did the other. The difference is just as noticeable in a succeeding corn crop. The husks, cobs, stalks, and leaves all remain on the land, and these, with the manure from the hogs, enrich the soil and increase its humus content.

The health of the hog is an important consideration. Hogs that have plenty of range and exercise are not nearly so susceptible to disease as those confined in a small pen. A hog that goes out after his feed will be well grown and thrifty, accustomed to exposure, and not liable to be injured by a sudden change of weather.

It is difficult, however, to put a good finish on hogs while running in a large field or pasture. If they are allowed to run until three weeks or a month before sending to market, and are then shut up and given all the corn they want, with plenty of pure water, they will make very rapid gains. This man allows his pigs to run in the corn as soon as it is cultivated the last time, but does not let the older hogs into the field until the corn is in good condition to feed in the fall. He says he has also had good results from letting cattle into the corn first and following these with hogs.

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FARMERS' BULLETIN 332.

NUTS AND THEIR USES AS FOOD.

[Corrected to April 20, 1910.]

BY

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PREPARED UNDER THE SUPERVISION OF THE OFFICE OF EXPERIMENT STATIONS,
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., June 3, 1908.

Sir: I have the honor to transmit herewith and to recommend for publication as Farmers' Bulletin 332 an article on nuts and their uses as food, prepared by M. E. Jaffa, professor of nutrition of the University of California.

The present bulletin is a revision and extension of an article by Professor Jaffa bearing the same title which was published in the Yearbook of the Department for 1906, and constitutes a summary of available data on the flavor, composition, and digestibility of nuts and nut products, and on the general subject of nuts and their uses as food. For a number of years Professor Jaffa has studied the question of the food value of nuts and nut products as a part of the cooperative nutrition investigations of this Office and in this bulletin has drawn largely on the results of this work. The present bulletin is similar in purpose and scope to the popular publications which the Department has issued in the past summarizing available information on different food materials.

Respectfully,
A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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NUTS AND THEIR USES AS FOOD.

INTRODUCTION.

The constantly increasing consumption of nuts throughout the United States augurs well for a better appreciation of their food value. The time when nuts were considered merely as a luxury, or as something to be eaten out of hand at odd times, is rapidly passing away. In earlier days the native hickories, butternuts, walnuts, chestnuts, pecans, and many other nuts found in the United States were to be had in country regions for the gathering and were of no commercial importance. On the other hand, the English walnuts (to give them their most common name), almonds, cocoanuts, etc., brought from other countries, were relatively expensive luxuries.

Some nuts, like the native hazelnut and beechnut, still have practically no commercial value and, though palatable, are almost never offered for sale, doubtless because they are so small and difficult to gather in quantity. The chinquapin, a small nut allied to the chestnut, finds a limited sale in southern cities, but is doubtless seldom if ever seen in other markets. In general, however, conditions have changed and our principal native nuts are now staple market commodities and bring good prices. At the same time, owing to changes in market conditions, and to the growing of foreign nuts in quantity in this country, the price of the imported nuts has dropped so that they are well within the reach of the majority.

From available statistics it appears that in 1905 the total quantity of almonds, cocoanuts, Brazil nuts, filberts, peanuts, walnuts, and other nuts, shelled and unshelled, imported into the United States was, in round numbers, 86,238,000 pounds, with a value of $6,138,000. In 1905 the total almond crop in California reached 4,200,000 pounds and the walnut crop 12,800,000 pounds. The richest yield of peanuts was reported from the Southern States, chiefly Virginia, Georgia, and Tennessee, and amounted to 225,000,000 pounds.

The total quantity of home-grown nuts, including both native and ntroduced varieties, must far exceed the quantities imported, but in he nature of the case no estimates of the total quantities gathered nd eaten are procurable. When we consider the constantly increasng demand for nuts and the large quantity which we import from other countries, the possibilities of the industry for the American nut grower are obvious. As the use of nuts has increased, many persons have turned their attention to the growing of native and foreign nuts on a commercial scale. This work has been forwarded by the Department of Agriculture, through the Bureau of Plant Industry, and by the California, Florida, Michigan, and other agricultural experiment stations. With nuts, as with other crops, it has been found that, by selection and breeding, improved varieties are obtainable, of larger size, better flavor, thinner shells, or other desirable characteristics.

The increased demand for nuts is due in the main to two causes, namely, a better appreciation of their appetizing qualities and the numerous ways in which they form a palatable addition to the diet of the average family, and, secondly, to their use by the vegetarians and persons of similar belief—a group small in proportion to the total population, but still fairly large numerically—who use nuts, and more particularly the peanut, as a substitute for meat and other nitrogenous and fatty foods.

Even a cursory examination of the journals devoted to cookery and other branches of home economics and of the various books which are published on the subject will show the fairly general use of nuts for making soups, for stuffing poultry, for nut butters, nut salads, cakes, salted nuts, and other dishes, and indeed several volumes devoted exclusively to nut cookery have been published.

Many special nut foods, such as malted nuts, meat substitutes, etc., have been devised and extensively advertised by the manufacturers for general use in the diet and for the special needs of vegetarians and fruitarians. It is said that some of these American nut products contain soy beans, but apparently the peanut plays a very important part in their composition. In either case, since the peanut, like the soy bean, is a legume, these preparations might more properly be compared with the bean cheese and other soy-bean products, so much used in China, Japan, and other eastern countries, than with such nuts as the walnut, almond, or cocoanut.

DESCRIPTION OF NUTS.

The term "nut" is not a definite one botanically speaking, but is applied indiscriminately to a variety of certain fruits or parts of fruits and implies a more or less hard, woody covering surrounding a meat or kernel. The most diverse plant groups contribute to our nut supply, many of the common nuts being the product of our beech, chestnut, walnut, and other deciduous trees and bushes. Not a few of the nuts which are eaten in large quantities are obtained from pines and tropical palms, while others, like the peanut and pistache or pistachio, are obtained from leguminous plants, being the fruit, respectively, of a vine-like plant and a small tree. Still another, the water chestnut, is supplied by a water plant.

Most of the native and foreign nuts which we find in our markets are too familiar to need description. Several, however, are not so generally known.

Pine nuts, which grow in the cones of a number of varieties of native and foreign pines, are now fairly common in our markets. The Indians have always known and appreciated them and have passed on their knowledge to the white race. Then, too, many immigrants who came to this country knew the pine nut, for it has long been much eaten in Italy and other parts of southern Europe where there are a number of nut-yielding pines. A variety of pine nuts is used in India by natives and Europeans sometimes pounded and mixed with honey and sometimes like other nuts as dessert. In this country the small, rather pointed pine (piñon) nuts which are most common are usually marketed shelled, but as they grow are covered with a more or less hard, woody shell. The pistache nut (now grown in California) has long been used and is prized by confectioners for its delicate flavor and attractive green color, yet it is by no means common. The nuts are small, not unlike a bean in size and shape, though more pointed, and before marketing are freed from the pods in which they grow. The individual nuts are covered with a gray or purplish skin, and are blanched before they are used.

The so-called lichi nut, which is really a dried fruit surrounded by a nut-like shell and not unlike a raisin in flavor, is a favorite in China and has become quite common in this country since its introduction by the Chinese. The ginkgo nut, the fruit of an ornamental tree quite widely grown in the United States and sometimes called the maidenhair tree from the shape of the leaves, and which fruits abundantly in some regions, is seldom eaten except by the Chinese, who gather it whenever possible. The small, roundish, oval, thin-shelled nut is surrounded by a very acrid, bad-smelling pulp, the whole fruit being not unlike a green damson plum in size and appearance. In China, Korea, and other parts of the Orient this nut is much used as a food, but, so far as can be learned, is always cooked in some way. Roasted like a peanut, it has a pleasant flavor. The ginkgo nuts are on sale in the Chinese shops in San Francisco and doubtless in other cities, and were studied at the California experiment station some years ago, together with a number of other typical Chinese food materials.

The water chestnut, or horn chestnut (*Trapa bispinosa*), an aquatic plant, produces a seed or "nut" which somewhat resembles two curved horns united in one, the kernel of which is largely used as a food by the inhabitants of Asiatic countries. This so-called nut is also on sale in the United States, but chiefly in Chinese shops. Another water plant (*Eleocharis tuberosa*) is also known as the water chestnut, but in this case it is the corm or bulb that is eaten. It is not unlike a chestnut in shape, and has a tough, brown skin. This is grown in Asia, but is imported by the Chinese in this country. A pointed nut or seed somewhat like a pecan in appearance, the pit of the Chinese olive (*Canarium* sp.), is also on sale at Chinese shops in the United States. The kernels are oily but palatable, resembling the common American butternut (*Juglans cinerea*) in flavor. Closely related species of Canarium nuts are also imported to some extent for general trade, though they are by no means common. The use of a "milk" or emulsion made from these nuts as an infant food is spoken of elsewhere (p. 20).

The candle nut of the Tropics is very oily, and after it has been stored for some time and is thoroughly dried is edible and by many considered palatable. If eaten too soon, however, the croton-oil-like body which it contains generally causes very serious illness. The chufa, nut grass, or earth almond is a small tuberous root of a sedge-like plant and may, perhaps, be classed more properly with the vegetables than with the nuts. It is not common, though eaten to some extent.

From time to time new nuts make their appearance on the market as some nut prized locally becomes known to the trade. A nut which seems to be growing in popularity, though still uncommon, is the Paradise nut of South America, which resembles a Brazil nut in appearance and flavor. Still less common is the South African cream nut, though it is sometimes shipped to this country. The choicest member of the Brazil-nut group is the true "butternut" of the Tropics, which is very seldom found outside that region. Its flavor is very delicate and delicious, but it does not keep well; and even if it would bear shipment successfully, the available supply is at present very small. The cashew nut of tropical regions, which many consider one of the most delicious nuts grown, has long been known. The roasted nuts both salted and plain are on sale rather commonly by dealers in fruits and nuts and the demand for them is increasing. Cashew-nut candy is also sold in a limited way in the United States. This nut must be roasted before it is eaten, as when raw it has poisoning properties which are, however, readily destroyed by heat.

The Kingsland chestnut was almost unknown a few years ago, but is now being cultivated in California. It somewhat resembles a filbert in appearance and is not a true chestnut. The tabebuia (*Telfairia pedata*), from Zanzibar, is a nut eaten roasted, which has been grown in a very limited way at the Porto Rico Agricultural Experiment Station, and is almost unknown, except in the region where it is native.

The so-called nuts are the seeds of a pumpkin-like fruit, and are oval, rather flat, and much larger than pumpkin seeds. The flavor is oily and fairly palatable. Should a demand arise it could be supplied by Porto Rican growers. The use of such a seed as a nut suggests the common use in Russia of the sunflower seed, which is rich in oil and not unlike some of the common nuts in composition. The raw sunflower seeds are eaten out of hand at all times and by all classes. In China watermelon seeds are eaten in the same way.

THE FLAVOR OF NUTS.

The flavor of nuts is very largely dependent upon the oils which they contain, though in some there are also specific flavoring bodies. The nut oils readily become rancid, the very disagreeable flavor of spoiled nuts being due to this property. Some nuts (for instance, the chestnut) have a starchy flavor as well as a "nutty" taste. The small native nut is much more highly flavored than the large Italian or the Japanese chestnut. The almond possesses the cyanic-acid flavor, which is characteristic of peach pits, plum pits, etc., and this might be expected when it is remembered that the almond is the dried pit of an inedible fruit somewhat resembling the peach in appearance and closely related to it botanically. Most almonds are mild flavored. The so-called bitter almonds are, however, very strong, the cyanic acid yielding glucosid being present in considerable quantity. In raw peanuts there is a decided flavor resembling that of the closely related beans and peas, and to some persons this is not unpalatable. In the roasted peanut, which most of us prefer to the raw, the flavor is largely dependent upon the browned oils and starches or other carbohydrates.

COMPOSITION OF NUTS.

The composition of nuts and nut products has been studied at a number of the agricultural experiment stations, notably California, Maine, and Iowa, and the following table summarizes the results of this work, the American data being supplemented in a number of cases by the results of European analyses. For purposes of comparison several other common food materials are also included.

Average composition of nuts and nut products.

Kind of food.	Refuse.	Edible portion.						
		Water.	Protein.	Fat.	Carbohydrates. Sugar, starch, etc.	Carbohydrates. Crude fiber.	Ash.	Fuel value per pound.
Nuts and nut products:	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Calories.*
Acorn, fresh	17.80	34.7	4.4	4.7	50.4	4.2	1.6	1,265
Almond	47.00	4.9	21.4	54.4	13.8	3.0	2.5	2,895
Beechnut	36.90	6.6	21.8	49.9	18.0		3.7	2,740
Brazil nut	49.35	4.7	17.4	65.0	5.7	3.9	3.3	3,120
Butternut	86.40	4.5	27.9	61.2	3.4		3.0	3,370
Candle nut	....	5.9	21.4	61.7	4.9	2.8	3.3	3,020
Chestnut, fresh	15.70	43.4	6.4	6.0	41.3	1.5	1.4	1,140
Chestnut, dry	23.40	6.1	10.7	7.8	70.1	2.9	2.4	1,840
Horn chestnut or water chestnut	....	10.6	10.9	.7	73.8	1.4	2.6	1,540
Chufa (earth almond)	....	2.2	3.5	31.6	50.2	10.5	2.0	2,435
Cocoanut	34.66	13.0	6.6	56.2	13.7	8.9	1.6	2,805
Filbert	52.08	5.4	16.5	64.0	11.7		2.4	3,100
Ginkgo nut (seeds)	....	47.3	5.9	.8	43.1	.9	2.0	940
Hickory nut	62.20	3.7	15.4	67.4	11.4		2.1	3,345
Lichi nut	41.60	16.4	2.9	.8	78.0		1.9	1,510
Paradise nut	45.70	2.3	22.2	62.6	10.2		2.7	3,380
Peanut	27.04	7.4	29.8	43.5	14.7	2.4	2.2	2,610
Pecan	50.10	3.4	12.1	70.7	8.5	3.7	1.6	3,300
Pine nut, Piñon	40.6	3.4	14.6	61.9	17.3	....	2.8	3,205
Pine nut, Spanish, or pignolia (shelled)	....	6.2	33.9	48.2	6.5	1.4	3.8	2,710
Pistachio	....	4.2	22.6	54.5	15.6		3.1	3,250
Walnut	58.80	3.4	18.2	60.7	13.7	2.3	1.7	3,075
Almond butter	....	2.2	21.7	61.5	11.6		3.0	3,340
Almond paste	....	24.2	13.1	23.9	29.4	7.8	1.6	1,900
Peanut butter	....	2.1	29.3	46.5	17.1		5.0	2,825
Malted nuts	....	2.6	23.7	27.6	43.9		2.2	2,600
Cocoanut candy	....	3.9	2.4	11.9	76.7	4.5	.6	2,000
Peanut candy	....	3.0	10.3	16.6	66.9	2.1	1.1	2,115
Chestnuts, preserved (marron glacé), air dried	....	18.2	1.3	.5	79.7		.3	1,530
Walnuts preserved in sirup, air dried	....	16.9	13.6	20.0	48.6		.9	2,780
Cocoanut milk	....	92.7	.4	1.5	4.6		.8	155
Cocoanut, desiccated	....	3.5	6.3	57.4	31.5		1.3	3,125
Peanut coffee made from entire kernel	....	5.1	27.9	50.1	12.3	2.4	2.2	2,805
Almond meal	....	8.5	50.6	15.6	16.0	2.9	6.4	....
Commercial nut meal	....	3.0	29.0	51.7	12.1	2.0	2.2	....
Chestnut flour	....	7.8	4.6	3.4	80.8		3.4	1,790
Cocoanut flour	....	14.4	20.6	2.1	45.9	10.1	6.9	1,480
Hazelnut meal	....	2.7	11.7	65.6	17.8		2.2	3,185
Almond diabetic biscuit [a]	....	5.3	29.0	8.8	54.3	.5	2.1	....
Commercial meat substitute [b]	....	55.2	12.7	21.8	6.3	1.8	2.2	....
Do.[b]	....	62.2	22.6	9.2	3.6	.9	1.5	....
Other foods for comparison:								
Meat, round steak	....	65.5	19.8	13.6	....	....	1.1	950
Cheese, cheddar	....	27.4	27.7	36.8	4.1	....	4.0	2,145
Eggs, boiled	11.20	65.0	12.4	10.7	....	....	.7	680
Wheat flour, high grade	....	12.0	11.4	1.0	74.8	.3	.5	1,650
White bread	....	35.3	9.2	1.3	52.6	.5	1.1	1,215
Beans, dried	....	12.6	22.5	1.8	55.2	4.4	3.5	1,605
Potatoes	20.00	78.3	2.2	.1	18.0	.4	1.0	385
Apples	25.00	84.6	.4	.5	13.0	1.2	.3	290
Raisins	10.00	14.6	2.6	3.3	73.6	2.5	3.4	1,605

[a] Contains some wheat gluten.

[b] It is claimed that such goods are nut products.

Refuse, mostly shell, constitutes a considerable proportion of the nuts as purchased, varying greatly with the different kinds. With fresh chestnuts the proportion is nearly 16 per cent, dry chestnuts 23 per cent, peanuts 27 per cent, almonds 47 per cent, and butternuts 86 per cent.

The edible portion of nuts, with few exceptions, is very concentrated food, containing little water and much fat. In general, nuts are also rich in protein. Those ranking highest in this nutrient, the pignolia, a variety of pine nut imported from Spain, with 33.9 per cent, the peanut with 29.8 per cent, and the butternut with 27.9 per cent protein, surpass most ordinary animal or vegetable foods in this respect. The almond, beechnut, and pistachio, with 21.4 per cent, 21.8 per cent, and 22.6 per cent, respectively, compare favorably with dried legumes. The Brazil nut contains 17.4 per cent protein, the filbert 16.5 per cent, the walnut 18.2 per cent, the hickory nut 15.4 per cent, the pinenut 14.6 per cent, the pecan 12.1 per cent, and the dry chestnut but 10.7 per cent. The dry acorn, fresh chestnut, and cocoanut, with 6.4, 6.4, and 6.6 per cent, respectively, are not as rich in protein as bread.

Of the nuts here included the richest in fat is the pecan, with an average of 70.7 per cent, but 7 other varieties—the Brazil nut, butternut, candlenut, filbert, hickory nut, pinenut, and walnut—contain upward of 60 per cent. The almond, cocoanut, and pistachio yield between 50 and 60 per cent of this nutrient. The beechnut, peanut, and pignolia contain about 50 per cent. In other words, in 13 of the varieties of nuts appearing in the foregoing table, half or more of the edible portion is fat or oil.

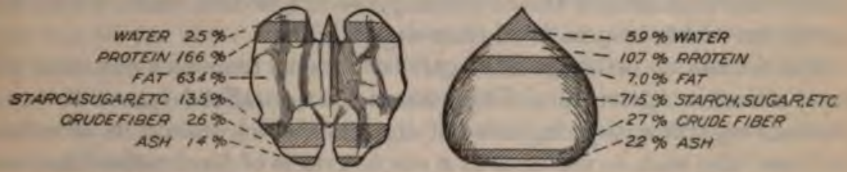

FIG. 1.—Percentage composition of an oily nut (walnut) and a starchy nut (chestnut).

Only a few of the commonly used nuts yield any notable amounts of total carbohydrate matter, the dry chestnut, with 73 per cent, rating highest. Beechnuts, pinenuts, and peanuts have about 18 per cent. The quantity of starch found is, with some exceptions, quite small, ranging from 3 per cent in the beechnut to 27 per cent in the chestnut.

Figure 1 shows in diagrammatic form the percentage composition of an oily nut, the walnut, and a starchy nut, the chestnut.

Nuts are, comparatively speaking, well supplied with mineral matter, this constituent in the majority of nuts exceeding 2 per cent. The ash of the walnut, almond, etc., is rich in phosphoric acid, and in this regard compares favorably with that of cereals. It would appear from the data on the digestibility of nuts that the mineral matter is as well assimilated as that from other common foods.

It is a matter of observation that the nuts of any given species produced in different regions, and indeed those from different trees of any given region, vary decidedly in size, flavor, and composition, the hickory nuts, for instance, from one tree being much more oily than those from another in the same locality. Advantage is taken of such natural variations in selecting wild nuts for cultivation, notably in the case of pecans, where the range in size and quality is very noticeable.

DIGESTIBILITY OF NUTS.

With the exception, perhaps, of certain rich pies and puddings, no food material has the reputation for indigestibility that has been accorded to nuts. Discomfort from them is certainly not uncommon, and when it occurs it seems fair to say is largely due to insufficient mastication and to the fact that nuts are often eaten when not needed, as after a hearty meal or late at night; though it is undoubtedly true that nut protein as ordinarily eaten is not so easily or so completely digested as meat protein. Very likely the concentration of nuts, with but 3 to 5 per cent water, as compared with meats containing from 50 to 70 per cent water, is a contributing cause. If careful consideration were given to this matter and if attention were paid to the proper use of nuts and their correct place in the diet, there would be less unfavorable comment on their digestibility.

The results of investigations carried on with fruit and nut diets at the California Agricultural Experiment Station afford tentative conclusions regarding thoroughness of digestion which should be of value to those who wish to use nuts as a staple article of food rather than as an occasional article of diet. This work has comprised 15 dietary studies and about 100 digestion experiments with elderly men, young men, women, and children, of whom some had been vegetarians for years, and some had even limited their diet almost exclusively to fruit and nuts; others had previously lived on the usual mixed diet. The average coefficients of digestibility reported for 28 experiments with 2 men and 1 woman on a fruit and nut diet were: Protein, 90 per cent; fat, 85 per cent; sugar, starch, etc., 96 per cent; crude fiber, 54 per cent; and ash, 68 per cent, with 86 per cent of the energy available. The corresponding figures for three experiments with the same subjects in which no fruit or nuts were used are: Protein, 94 per cent; fat, 92 per cent; sugar, starch, etc., 96 per cent; crude fiber, 49 per cent, with 88 per cent of the energy available. The latter coefficients agree very closely with those in the average of nearly 500 experiments with different sorts of mixed diet, namely: Protein, 92 per cent; fat, 95 per cent; and carbohydrates, 97 per cent.

Nuts were the main source of protein for the fruitarians, and it will be noted that this constituent had practically the same coefficient of digestibility in the nut and fruit diet as in the other cases cited. The studies with fruitarians have all indicated that nut protein is fairly well assimilated; and that this is true with the average healthy person is well illustrated by an experiment with a university student, who, though entirely unaccustomed to such fare, gradually changed from an ordinary mixed diet to one of fruit and nuts, which he followed for a time without apparent loss of health or strength.

It is somewhat difficult to arrive at definite conclusions regarding the actual percentage of nut protein digested or assimilated. The experimental data obtained at the California station show a range of 75 to 82 per cent digestible protein when fruit and nuts were eaten together, but the figure for nut protein is doubtless higher. These coefficients were in all probability influenced by the fruit protein, which has been found to be less digestible than the nut protein. The digestibility of protein in 28 experiments with mixed diets, to which were added fruit and nuts, averaged 90 per cent.

As fruits, with the exception of the avocado and olive, yield only a small amount of fat, the fat which is contained in a fruitarian diet must be very largely obtained from the nuts. The average coefficients of digestibility for this nutrient in 30 experiments with men on a diet of fruit and nuts was 86 per cent, and in 28 experiments just referred to it was 85 per cent. These figures are about 10 per cent lower than the average coefficient for digestibility of fats in the ordinary mixed diet. The digestibility of the carbohydrates in nuts, so far as the available data show, is about equal to that of the same ingredients in other foods.

So far as can be ascertained no experiments have been made on the ease or rapidity of digestion of nuts. In the absence of such data it is fair to assume that within reasonable limits the finer the state of subdivision of the food material the easier, the more rapid, and perhaps the more nearly complete will be the digestion or assimilation, presupposing, of course, that the nuts are not eaten in addition to a hearty meal. Too much stress can not be laid on the necessity of thorough mastication of nuts. This is emphasized by the results obtained with one of the subjects at the California station, a man at moderately active work, who ate largely of nuts but did not properly masticate his food. The coefficients of digestibility of the food were far lower than for other subjects who chewed their food thoroughly. The experiments with fruit and nut diets in general indicate that nut protein is as easily, even if not quite so completely, digested as protein from bread and milk.

The present discussion refers only to the nuts included in the studies at the California station, viz, the almond, Brazil nut, cocoanut, peanut, pecan, pignolia, and walnut. It is believed that these are typical of the ordinary edible nuts, but further digestion experiments are much needed for the purpose of testing some other nuts.

As regards the work of other investigators, both Memmo[a] and Merrill[b] report digestion experiments with cooked chestnuts. Memmo's subject was a farm laborer, 53 years old, working eight hours a day. The experiment lasted four days. During the first two the food consisted exclusively of chestnut products. This was modified during the last two days by the addition of herring and cheese. In this experiment 75 per cent of the protein, 87 per cent of the fat, 97 per cent of the total carbohydrates, and 83 per cent of the ash were assimilated. The last figure is exceptionally high; the others correspond to those reported for the California experiments with men on a fruit and nut diet.

The subjects of Merrill's experiments were two men aged 23 and 34 years, respectively. A mixed diet was used. Each subject consumed daily 300 grams of the cooked chestnut flour, which furnished about 20 per cent of the proteids, 50 per cent of the fat, nearly 50 per cent of the carbohydrates, and not far from 40 per cent of the total fuel value of the food. The average digestion coefficients obtained for chestnuts with the two subjects were protein 56 per cent, fat 63 per cent, and total carbohydrates 98 per cent, while 89 per cent of the energy was available. Memmo also studied a kind of acorn bread eaten in Italy, and found it was fairly well assimilated, though not very palatable. In experiments made by Saiki[c] at Yale University chestnuts were added to the diet to obtain data regarding the raw chestnut starch, and it was found that it was comparatively indigestible. This would suggest that it is desirable to cook chestnuts rather than to use them raw.

From the foregoing it would appear that, while it is not possible to determine the exact digestion coefficients for all nuts, enough has been done to indicate their high nutritive value and to show that the human system can assimilate a very large proportion of the nutriment contained in nuts when they are rationally eaten.

PLACE OF NUTS IN THE DIET.

It has been shown by numerous investigations that nuts are rich in protein and fat and that these nutrients can be fairly well assimilated. Nuts being such a concentrated food, their proper place in the diet is a matter for more careful consideration than is the case with many of the ordinary food materials. It must not be forgotten that a certain bulkiness of the diet is conducive to its normal assimilation, and that too concentrated nutriment is often the cause of digestive disturbances. It might be expected, then, that nuts could be most advantageously used in connection with more bulky foods, such as fruits, vegetables, breads, crackers, etc. Most rationally used, they should constitute an integral part of the menu rather than supplement an already abundant meal. Since nuts are so concentrated, eating a considerable quantity out of hand at odd times will mean an oversupply of food if a corresponding reduction is not made in the quantity of other foods eaten during the day. The distress sometimes experienced when nuts are eaten is undoubtedly often due to improper mastication or to overindulgence, since investigations made at the California station indicate clearly that considerable quantities of nuts properly eaten do not cause distress. There is a popular belief that a little salt with nuts prevents the digestive disturbance resulting from eating them. To most persons salt undoubtedly adds to the palatability of the nuts, but no investigations have been found on record which demonstrate any actual improvement in the digestibility of nuts due to salt.

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[a] Ann. Inst. Ig. Sper. Univ. Roma, n. s., 4 (1894), p. 263.

[b] Maine Sta. Bul. 131, p. 146.

[c] Jour. Biol. Chem., 2 (1906), p. 251.

Considering all kinds, nuts are perhaps more often eaten raw than cooked, though some sorts like the peanut, which is not generally considered palatable raw, and the cashew nut, which is poisonous until roasted, are quite generally cooked.

In this country the native chestnut is very commonly eaten raw, and the small native nuts have a distinct and characteristic flavor. The European chestnut, when raw, is lacking in flavor and so is almost universally cooked. The Japanese chestnut is much like the European in its characteristics.

The cocoanut and the almond are important ingredients of many sorts of cakes and confectionery, and often nuts are used in cooking in many ways.

Nuts may be readily used as staple articles of diet, as an ingredient in salads and in soups, as a stuffing for poultry, in the making of desserts, and in many other ways. Wild turkey stuffed with pecan nuts is a dish popular with old Virginia cooks, just as goose stuffed with chestnuts is prized in Germany. Salted nuts and nuts crystallized in sugar are very common accompaniments of other foods. In general, the nuts rich in protein and fat should be used in combination with carbohydrate foods, as bread, fruit, green vegetables, etc., while such nuts as the chestnut, which do not contain much protein or fat, but are rich in carbohydrates, may be properly combined with meats, milk and cream, eggs, and other foods containing protein and fat.

Since nuts are relished by most persons, are nutritious, and may be readily used by themselves and in various palatable combinations as an integral part of the diet, they have a legitimate place in the menu. Those who, for any reason, wish to live on vegetable foods and dairy products or any form of vegetarian or fruitarian diet will almost inevitably look to nuts, particularly such as the peanut, for a considerable portion of their total nutritive material. A fruit and nut diet may be arranged to furnish sufficient protein, mainly from nuts, to satisfy the requirements of the body, but the consensus of opinion of well-informed physiologists seems to be that such a diet is not generally advisable nor to be recommended for the majority of mankind in place of the more usual mixed diet. It should also be remembered that numerous experiments have shown that the protein from mixed diet has a higher coefficient of digestibility than nut protein, which indicates that the protein of nuts is the less economically utilized by the body. The argument which is so often advanced that primitive man lived on nuts and fruits exclusively and hence his descendants should do so is not generally accepted.

The comparatively high price of many of the edible nuts, particularly when shelled, and the difficulty of cracking some varieties—like pecans, black walnuts, and hickory nuts—and extracting the kernels at home, greatly militate against the freer use of nuts in the household. The consumption of peanuts and English walnuts is perhaps increasing faster than that of some other nuts; but, whatever sort is selected, they should, as already noted, form a part of the diet and not supplement an already sufficient meal.

NUTS AND NUT PRODUCTS FOR DIABETICS.

Nuts and nut products are often recommended as foods for diabetics and others from whose diet starch and sugar are excluded, or at least materially reduced. On this subject the following statements are made by A. L. Winton,[a] in a report of studies made at the Connecticut State experiment station of the composition of diabetic foods, chiefly commercial products:

> Most of the nuts, including walnuts, Brazil nuts, almonds, and filberts, since they contain no starch and only small amounts of sugar and dextrin but are rich in protein and oil, are valuable additions to the diet of diabetics. Almond meal is used in the preparation of various biscuits and bread substitutes. The chestnut is a notable exception among nuts, in that it is rich in starch and poor in fat, the composition of the shelled nut being much the same as that of wheat flour; it is therefore entirely unsuited for the use of diabetics. * * *
>
> The peanut, * * * although very rich in oil, contains about 11 per cent of starch, sugar, and dextrin, of which about half is starch.

NUT BUTTERS AND NUT MILK.

Within the last few years so-called nut butters have been used in increasingly large amounts, and at least one variety, namely, peanut butter, is made and sold in ton lots. It has already been stated that in order to insure the best physiological results from the dietetic use of nuts they should be thoroughly ground up by the teeth and that, other things being equal, the digestion coefficient will vary directly with the fineness of division. The nut butters, made as they are from the finely ground nuts with or without the addition of some water, oil, and salt, have a homogeneous consistency not unlike true butter, and when properly made the material is so finely divided that even if it is not thoroughly chewed it will presumably offer much less resistence to the digestive juices than nuts hastily eaten. Nuts, and hence nut butters, are very rich in fat, which readily becomes rancid and unpalatable. This is doubtless one of the reasons why nut butters are quite commonly marketed in jars, etc., containing small amounts which may be utilized in a short time. The nut butters are recommended by vegetarians as a substitute for butter in culinary processes and for use at the table. By persons who are not vegetarians they are commonly used for making sandwiches and in other ways for their agreeable flavor and for the pleasing variety which they give the diet.

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[a] Connecticut State Sta. Rpt. 1906, p. 153.

Nut butter may be easily made at home. The nuts may be pounded in a mortar, but a mill for grinding them is much more convenient and may be readily procured, as there are a number of sorts on the market. The process of making nut butters has been frequently described in journals and cookery books. Either the raw or the roasted peanut may be used for making peanut butter, but the roasted nut is the more satisfactory. The kernels should be freed from chaff and reduced to a paste in the grinding mill. Freshly roasted nuts are necessary, as those which have stood for a day or so after roasting lose in crispness, do not grind well, and tend to clog the mill. Any sort of nut may be used, but experience has shown that it is more difficult to make butters from the almond or Brazil nut than from the peanut. Blanching these nuts requires considerably more time and labor than is needed to free the peanut from the skin which covers the kernel, and they are also more difficult to grind. Nut butters will keep well if sealed in glass or earthenware jars. Tin cans also may be used, but are not quite as desirable. As might be expected, nut butters do not differ materially in composition from the nuts from which they are ground. (See table, p. 12.)

The nut butters just mentioned are entirely different from cocoanut butter or from cocoa butter, which are expressed and purified fats. Cocoanut butter, which is sold under a variety of trade names, is made, it is said, by extracting and refining the fat from the sliced and dried cocoanut or copra. Its natural color is white, and it is solid at ordinary temperatures, resembling refined beef fat in appearance. It is used as a substitute for butter and in various culinary ways. Chocolate and cocoa, as is well known, are both products of the cocoa bean, the former being much richer in fat than the latter. The fat which is extracted in the manufacture of cocoa is called cocoa butter and is used as a culinary fat and for other purposes. It is an entirely different product from the cocoanut butter mentioned above.

The liquid in the cocoanut, often called cocoanut milk, is not at all the same as the nut milks often referred to in books devoted to nut cookery, which may be made by mixing nut butter of any given sort with water.

By pouring a pint of boiling water on a freshly grated cocoanut, allowing it to stand until cold and then straining it, a milky liquid is obtained which is also sometimes called cocoanut milk or cream and is used in cooking and other ways in regions where cocoanuts are grown. On standing, the fatty portion rises to the top as cream rises on milk. Cocoanut cream may be served with fruits and used in other ways. These cocoanut products and similar articles made from other nuts are used to some extent by the strict vegetarians who do not care to use cows' milk.

A similar nut milk or emulsion of nut fat made from Java almonds (a species of Canarium) is used in Java, apparently with considerable success, as an infant food.

NUT PASTES AND NUT PRESERVES.

Pastes which are used by confectioners for candy making and in other ways are made from nuts with the addition of sugar. Sometimes water and starch are added, but such admixtures are inferior to the nut and sugar pastes. The most common material of this sort is the almond paste, which is manufactured in large quantities in the United States and is also imported. It is used for making cakes, candies, etc., the highly ornamented cakes called "marzipan," so popular with the Germans, being one of the very well-known almond-paste confections.

Macaroons are also well-known cakes made from ground almonds or almond paste. Cocoanut is also used for the same sort of cakes.

Chestnuts preserved or candied in sirup and then dried, the marrons glacé of the confectioners, are esteemed a delicacy and are eaten alone or are used in confectionery, etc. Thus prepared they are a common commercial article. Much less common are the English walnut meats preserved in sirup, which are manufactured in Europe and exported to this country in limited quantities. Preserved nuts which are similar to these are made in this country, particularly for the soda-water trade. Often maple sirup is used instead of ordinary sirup. Nut sirups, in which the ground nuts are incorporated with the sirup, are also well known for the same purpose, and are quite similar to the nut bisques or similar pudding sauces made at home.

As the data in the table on page 12 show, such nut preserves are rich in carbohydrates, owing to the added sugar. In Germany walnut meats and spice are often added to the plum butter which is made in such quantities in many homes. In the Tropics a thick, sweet preserve is made from cocoanut and sugar which is much liked locally, though those who are not familiar with it consider it very sweet and insipid. The Turks make several products from walnut meats and grape juice which are considered wholesome and palatable foods. In one of these the nuts are strung on a strong thread and dipped in thickened grape juice until well coated with it.

NUT FLOURS AND MEALS.

Among nut products may be mentioned nut flours and meals. Some of these are used in large quantities and are made on a commercial scale, while others, perhaps owing to the trouble and expense incidental to manufacture, find only a limited use. In general, meals are made from the ordinary edible nuts by blanching, thoroughly drying, and grinding. By using a nut mill such meals may be ground at home. Analyses of some products of this character will be found in the table on page 12. Almond meal has been on the market for a long time, being used as food for diabetics (see p. 18) and for making cakes, etc., as well as in a number of technical ways.

Special mention should be made of chestnut flour, which is on sale in the United States and is used for most of the culinary purposes for which the fresh nut is recommended. In Italy it constitutes a considerable part of the diet, in some regions being extensively used for making a sort of bread or cake. One of the most complete studies of the dietetic use of chestnuts has been reported by Memmo.[a] According to the author, the chestnut often serves almost as the exclusive food of the peasants of Tuscany for a considerable part of the year. The whole nuts are eaten in a variety of ways; for instance, boiled in water without hulling, hulled and boiled, or roasted. From the flour various cakes and other foods are made. Sometimes dough made from chestnut flour and water is spread between chestnut leaves and baked in an oven, and sometimes the dough is baked between hot stones. Chestnut fritters are also used, though less commonly than the bread, as the oil needed to fry them is comparatively expensive. A half pound or more of chestnut flour made into porridge for breakfast, chestnut cakes for dinner, and chestnut porridge or macaroni for supper, with a little fish or cheese, is a common day's ration. Ground acorns, made into a sort of bread with the addition of about 75 per cent of flour, is a common article of diet in several regions, notably Umbria and Tuscany, but the bread is black and heavy and not very palatable.

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[a] Loc. cit. (see p. 16).

The early travelers and explorers make mention of the extended use of nuts by the American Indians, and the custom of using acorns as a staple food is still kept up. The methods of preparing acorns followed by the Indians of northern California have been described by P. E. Goddard [a] in a publication of the University of California, and by V. K. Chesnut,[b] formerly of the Department of Agriculture. Briefly speaking, the shelled nuts are split, dried, and ground with a mortar and pestle. The sifted flour is placed in a hollow in the sand on a convenient river bank and leached to free it from the bitter principles present. From the leached meal a porridge or mush is made, which to the ordinary palate is much improved by the addition of salt.

These typical Indian foods, when well prepared, are relished by many persons who have tried them, and it seems not improbable that improved methods of removing the tannin and bitter principles present in most varieties of acorns might result in the utilization of the acorn crop, which is fairly large throughout most regions of the United States and is generally wasted.

According to Chesnut's [c] investigations, the California buckeye or horse-chestnut is also used by the Indians as a food and is leached to free it from poisonous or objectionable matters in much the same way as the acorn. Many attempts have been made in Europe and elsewhere to treat the fruit of the common horse-chestnut in some way so that it might be made wholesome and palatable, for it undoubtedly contains an abundance of nutritive material, particularly starch; but none of these attempts has been really successful.

In many regions nuts are commonly added to ordinary bread dough, and such nut bread is a favorite and staple food. The use of partly extracted peanuts and other nut meals with wheat and rye flour for bread making should also be mentioned. Such breads have been used for patients with diabetes, but have never come into general use, perhaps because they are not very palatable, since the nuts become rancid so readily. In this connection the coarsely ground or shredded and dried cocoanut so common in our markets should be mentioned. Sugar is often added during the process of manufacture. Such prepared cocoanut is commonly used when it is not convenient to use the fresh nut. The cocoanut is much used in fancy cooking in the United States. In regions where it is grown it is a staple food. The pulp of the immature nut is considered a delicacy and is used in many ways. When frozen and served as an ice it is said to be especially delicious. The meat of the ripe nut is used in the preparation of a great variety of dishes, including sweets as well as other foods, and the cocoanut milk, particularly that of the unripe nut, is a very common and wholesome beverage. The so-called "milk" is in reality water which the plant stores in the nut and is very pure, containing only a little mineral matter, sugar, etc., in solution. In addition to the fact that it is palatable and usually cool, it is a much safer beverage than water from some possibly contaminated spring or stream.

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[a] Univ. Cal. Pubs., Amer. Arch. and Ethnol., 1 (1903), No. 1, p. 27.

[b] U. S. Dept. Agr., Div. Bot., Contrib. Nat. Herbarium, 7 (1902), p. 333.

[c] Loc. cit., p. 366.

NUT CANDIES.

One of the most extensive uses of nuts is in the manufacture of candy of various sorts, such as sugared almonds, burnt almonds, nut chocolates, caramels, pinoche, nut brittle, etc. While there are some differences in the process of manufacture followed in these candies, they all in the main consist of nuts and sugar in varying proportions, with flavoring extracts, and in some instances butter and flour. Perhaps the best known nut candy the world over is nougat, which is of oriental origin, and is a compound originally made of nuts and honey, but now more often of nuts and sugar. Usually almonds, filberts, pistachios, and pinenuts are employed in nougat making, but the kind of nut is necessarily very largely a matter of convenience. Sometimes burnt almonds are used instead of the blanched nuts. The nougat which our confectioners supply is soft in texture, but a brittle, hard sort is made in Europe and is imported to this country from Spain, the oblong blocks, about 6 by 4 by 2 inches, being wrapped in wafer and sealed in tins.

The table on page 12 shows the composition of common sorts of nut candy. As may be seen, the water content is low and these candies are highly concentrated foods. On account of the added sugar the carbohydrate content is high. The proportion of nuts used in candies varies. By assuming that the nuts furnish the bulk of the fat in the candy, it is estimated that nuts constituted about 50 per cent in the specimens analyzed. It is perhaps well to suggest that nut candies and other candies which sometimes cause digestive disturbances would be more satisfactory if eaten in a rational way and at the proper time. Since they are concentrated foods, they should naturally replace an equivalent amount of some other food material and not be eaten in quantity simply for their palatable flavor in addition to an otherwise adequate daily ration.

NUT COFFEES.

A number of coffee substitutes made from nuts have been devised and placed on the market, peanut coffee and acorn coffee being by far the most common. The nuts are parched and sometimes otherwise treated. Such coffee substitutes lack the stimulating properties of true coffee, and the infusion does not have the high nutritive value which is sometimes claimed for it.

GREEN NUTS.

A number of kinds of nuts are used before they are fully ripe, and are esteemed a delicacy. In California in spring the markets quite commonly offer green almonds—that is, the almonds picked from the tree while the husk is of a decided green color and easily separated from the soft and immature shell. The kernel, after the skin is peeled off, is eaten with or without salt, and is relished by many persons. The price of green almonds in California markets commonly varies from about 20 to 35 cents per pound. Green almonds are found to a limited extent in fancy fruit shops in Eastern cities and elsewhere, and are perhaps purchased as much for their ornamental appearance as for their palatability. They are much more commonly used in Europe than in the United States. Green English walnuts and green hazelnuts are also eaten to a considerable extent in Europe and are great favorites. The nuts are gathered when the shells are fully matured but not thoroughly ripe. Sometimes these green nuts are imported into the United States. Many who have grown up in the country will recall the delicate flavor of the immature butternut and hickory nut and the stained fingers which they caused. Such green nuts have apparently never been marketed.

Whole green walnuts and some other nuts are also used in a quite immature state for pickle making. They are picked when still tender enough to be easily pierced by a large pin; then, after being kept in brine for a number of days, they are exposed to the sun until they turn black. Afterwards they are placed in jars and covered with hot vinegar and spices. Sometimes they are treated with dry salt instead of brine before pickling. It is claimed that nuts thus treated will blacken without being exposed to sunlight. Such pickled nuts are considered by many as a very palatable relish for use with meats and poultry. Walnut catsup is also made from green walnuts.

NUT OILS AND OIL-CAKE MEALS.

In some parts of Europe almond oil, walnut oil, and beechnut oil are manufactured and prized as salad oils, and in South America Brazil-nut oil is used for table purposes. Cocoanut oil is an important oil in the Tropics. Peanut oil finds a large technical application and is also used in large quantities as a salad oil and for culinary purposes. Oils are also made from the kernel or nut of the peach and apricot, but these, like most nut oils except those mentioned, are used for medicinal or technical purposes rather than for food.

The various nut oils, which are practically pure fats, have a very high fuel value, and like olive oil and other oils, may constitute an important energy-yielding constituent of the diet. It is commonly assumed that, like olive oil, these oils are readily assimilated when properly combined with other food materials, as in salads, as "shortening" for various dishes, and in similar ways.

The oil-cake meals, as the ground products remaining after the expression of the nut oils are called, are much used as food for live stock and all kinds of poultry, and this is especially true of the peanut nd cocoanut oil cakes. It has been suggested that such oil-cake neals might be valuable dietary articles if properly manipulated, as hey of course contain a higher percentage of protein than the original ut. Some attempts have been made to thus utilize peanut-cake neal, but the results have not been very satisfactory.

PECUNIARY ECONOMY OF NUTS.

The composition and digestibility of nuts have been discussed in the foregoing pages, but little has been said regarding the cost of nutrients and energy which they supply as compared with other and more common food materials. The table which follows shows the comparative cost of a pound of protein and 1,000 calories of energy when furnished by different nuts and nut products and some other staple foods, and also the amounts of nutrients and energy which 10 cents' worth of these foods would supply, rating the foods at certain average prices per pound.

Pecuniary economy of nuts and nut products.

Kind of food.	Price per pound.	Cost of one pound protein.	Cost of 1,000 calories energy.	Amount for 10 cents.				
				Total weight of food material.	Protein.	Fat.	Carbohydrates.	Energy.
Nuts and nut products:	*Cents.*	*Dollars.*	*Cents.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Calories.*
Almonds	20	1.76	13.0	0.50	0.06	0.14	0.14	767
Brazil nuts	20	2.26	12.6	.50	.04	.16	.02	789
Chestnuts	8	1.48	8.3	1.25	.07	.06	.44	1,196
Cocoanuts	5	1.16	2.7	2.00	.08	.73	.29	3,662
Hickory nuts	9	1.55	7.1	1.11	.06	.28	.04	1,404
Peanuts	7	.32	3.6	1.43	.31	.45	.20	2,767
Pecans	15	2.47	9.1	.67	.04	.23	.04	1,003
Pignolias	25	.74	8.4	.40	.14	.20	.03	1,182
Pistachios	20	.88	6.1	.50	.11	.27	.08	1,124
Walnuts	20	2.66	16.0	.50	.04	.13	.03	633
Almond paste	40	3.17	21.0	.25	.08	.06	.10	475
Peanut butter	20	.68	7.1	.56	.15	.23	.09	1,412
Peanut candy	25	2.42	11.8	.40	.04	.07	.28	845
Other foods for comparison:								
Porterhouse steak	25	1.31	22.5	.40	.07	.07	....	444
Whole milk	4	1.21	12.0	2.50	.08	.10	.13	815
Cheddar cheese	16	.58	7.5	.62	.17	.23	.03	1,330
Wheat flour	3	.26	1.8	3.33	.38	.03	2.50	5,495
Beans, dried	5	.22	3.1	2.00	.45	.03	1.19	3,210
Potatoes	2	1.11	6.4	5.00	.09	....	.74	1,550

The common nuts—though, with the exception of the peanut, they are more expensive sources of protein and energy than meat and a number of the common foods—may yet be considered reasonably cheap sources of nutrients and energy, and hence may be regarded as justifiable additions to the diet on the score of economy. For the vegetarian or fruitarian, who looks to nuts as the chief source of protein in the diet, the peanut must be considered as much the most economical. As may be seen by a reference to the table, 10 cents will purchase more protein and energy when expended for the flours and meals than for any of the other foods, but it must be remembered in this connection that these are the raw materials requiring considerable preparation before they are palatable. This is not necessary with fruits and nuts, except in the case of the peanut and chestnut, which are usually roasted before they are considered palatable by most persons, though there are those who prefer them raw. When considering nuts, it is readily observed that 10 cents will buy about the same amount of nut protein as of animal protein, except in case of cheese and skim milk. If spent for peanuts, it will purchase more than twice the protein and six times the energy that could be bought for the same expenditure for porterhouse steak.

It is of more than passing interest to note that 10 cents' worth of peanuts will contain about 4 ounces (120 grams) of protein and 2,767 calories of energy, which is more protein and energy than is furnished by many rations regarded as adequate for a day. Although peanuts supply protein and energy for a smaller sum than bread, they are outranked by dried beans, which, at 5 cents a pound, will supply for 10 cents over 200 grams of protein and 3,200 calories of energy. If more peanuts and dried beans were used by fruitarians, their diet would be enriched and the cost decreased. The almond, so much in favor with fruitarians, furnishes for 10 cents about one-fourth the protein and less than one-third the energy supplied by peanuts.

HANDLING AND MARKETING NUTS.

Within the last few years the trade in shelled nuts has very markedly increased, and shelled walnuts, hickory nuts, almonds, English walnuts, pecans, etc., are now very commonly found in shops. The bulk of the nut crop is, however, marketed unshelled. Some of the unshelled nuts, notably pecans and peanuts, are very often polished before marketing by rotating them in rapidly revolving drums in such a way that the shells are worn down until they are more or less smooth. This method of treatment also removes any dirt and is supposed to make the nut more salable. It is worthy of note, however, that the highly prized, large fancy pecans are marketed without such treatment.

In cracking nuts, if one wishes to obtain the meats unbroken, it is necessary, as everyone knows, to hold the nut in such a position that the shell will be crushed along certain definite lines. Thus, hickory nuts must be struck on the thin side and pecan nuts and native butternuts or white walnuts on the end. With such nuts as the almond and filbert or cobnut less care is needed, as the nut is loose inside the shell. There are a number of machines for cracking nuts on a wholesale scale for market purposes, which give a very large proportion of unbroken nut meats. In most of these the nuts passing from a hopper to some device like an endless chain with pockets for holding them in the right position are crushed one at a time by automatically moving plungers. The machines which are used naturally vary in principle and in details of construction, one which would be satisfactory for a peanut or soft-shelled almond being less well adapted for use with such nuts as hickory nuts or pecans. Some of the machines used for peanuts and almonds are equipped with devices for removing the skin or hull which covers the nut meat.

In order to meet the market demand for clean and uniformly colored nuts, many nut growers have resorted to the process of bleaching their product. The first attempts in this direction were made by sulphuring—that is, by exposing the nuts to sulphur vapor. This treatment, though improving the color of the shell, proved injurious to the flavor of the nuts and lessened the keeping qualities. At the California Agricultural Experiment Station experiments with bleaching solutions have been carried on and very satisfactory results have been obtained with a mixture of sal soda, chlorid of lime, and water. According to reports of the imperial department of agriculture of the West Indies,[a] a similar process has been successfully used for bleaching peanuts. The consumer should bear in mind that the bleaching of nuts is entirely unnecessary and in no way increases their food value. The process is carried on solely for the purpose of improving the appearance of the nut, and thus commanding a higher price. It will doubtless be continued as long as the public is willing to be guided by appearance rather than food value. The term "bleaching," as applied to nuts, must not be confounded with the household term "blanching," which applies to the process of removing the skins from nut meats, as almonds and pistachio nuts, by immersing them for a short time in hot water and then rubbing off the skin.

Vegetables and fruits exposed for sale under ordinary conditions may be readily contaminated with bacteria, dirt, and dust. Nuts sold in their shells are protected in large measure from such contamination, yet many careful housewives wash, or at least wipe, the nuts which are to be cracked and served in the shells, as anything which adheres to the shell might readily contaminate the nuts after cracking, if all were mixed together in a dish.

Shelled nuts are now common commercial products. They are sometimes sold in tight packages, but more often are not thus protected from dust and insects, and should always be washed before they are used. Pouring hot water over nuts which are to be used for salad and other dishes is a practice which is recommended, as it removes any acrid taste and gives the nuts a fresh flavor and appearance.

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[a] Imp. Dept. Agr. West Indies Pamphlet No. 43, n. s.

If exposed to damp conditions, nuts mold and decay, and even under favorable conditions the nut oils and fats become rancid on long-continued storing. In the main, however, the keeping qualities of most nuts are excellent. Nuts, and particularly shelled nuts, should be stored in such a way that they may be free from attacks of insect enemies. When such precautions are not taken, "wormy" nuts are by no means uncommon.

SUMMARY.

Summarizing the foregoing data, it may be said that nuts are a very concentrated food, even more so than cheese, but when rationally used they are well assimilated and may form a part of a well-balanced diet. Nuts are a very valuable source of protein and fat, these two nutrients being the characteristic constituents of the most common nuts, of which the walnut and cocoanut may be taken as types. In nuts like the chestnut, carbohydrates are a characteristic constituent. For most families it is undoubtedly wiser to use nuts as part of the regular diet than as a condiment or supplement to an otherwise hearty meal.

Vegetarians and others who use nuts in place of meat should not depend upon them as the main food supply, but should supplement them with more bulky foods with a low content of protein and fat. As a whole, nuts may be classed among the staple foods and not simply as food accessories. At usual prices, nuts are reasonable sources of protein and energy. Peanuts supply protein and energy very cheaply, even compared with such staple foods as bread and beans. There are a number of nut foods on the market, but it may be stated that there is little to be gained from the standpoint of food value or economy in their use in place of the ordinary nuts and home-made nut products, especially by healthy persons who are willing to masticate their food thoroughly and to use nuts in reasonable combinations. Unless something has been added, the nutritive materials in such special preparations can not be greater than the nuts from which they are made, though in the mechanical condition or in some other way the foods may be better fitted for ready assimilation. Furthermore, nut butters and similar foods give a pleasant variety to the diet, and they are relished by many who would not care for the unprepared nuts.

Though less subject to contamination than many other foods, nuts should be handled and stored under good conditions, and especially should be protected from dampness and insect enemies.

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32. Silos and Silage.
34. Meats: Composition and Cooking.
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FARMERS' BULLETIN 333.

COTTON WILT.

BY

W. A. ORTON,
Pathologist, Bureau of Plant Industry.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., July 1, 1908.

Sir: I have the honor to submit herewith a paper entitled "Cotton Wilt," which has been prepared by Mr. W. A. Orton.

This paper deals with the essential details of this subject and outlines a successful means of combating the disease through the use of wilt-resistant varieties originated by the Bureau of Plant Industry as a result of nine years' work by Mr. Orton.

I recommend the publication of this manuscript as a Farmers' Bulletin.

Respectfully,
B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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COTTON WILT.

INTRODUCTION.

Names of disease known as "wilt."—The disease referred to in this bulletin has been known by other common names in various localities. It is the "blight" of the Carolina sea islands and other sections, the "frenching" described by Atkinson from Alabama, and the "blackheart" and "black-root" of the Gulf States. We shall refer to it as "wilt," because this is expressive and clear and was one of the first names applied to the disease.

This disease is quite distinct from the root-rot prevalent in the black lands of Texas, which also causes a wilting of the affected cotton plants. Neither is any reference intended here to wilting caused by drought alone.

History of wilt.—From the testimony of farmers and vague allusions in the United States Census and other reports it appears probable that the disease has been present in restricted localities in the cotton belt for at least twenty-five or thirty years. It has gained increasing headway in its spread during recent years, until complaints of loss are now frequent. The disease was not accurately described until 1892,[a] and the etiology and life history of the fungus were not worked out until studied by Dr. Erwin F. Smith, of the Bureau of Plant Industry, from 1895 to 1899.[b]

The work of this Bureau has been continued up to the present time to perfect measures for the control of this disease.[c] Corroborative experiments have been conducted by the Georgia State Board of Entomology[d] and by the Louisiana Experiment Station.[e] The present bulletin deals with practical aspects of the question with relation to Upland cotton only.

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[a] Atkinson, George F. "Frenching," in Some Diseases of Cotton. Bul. 41, Alabama Agricultural Experiment Station, pp. 19–29.

[b] Smith, Erwin F. Wilt Disease of Cotton, Watermelon, and Cowpea. Bul. 17, Div. Veg. Phys. and Path., U. S. Dept. Agriculture, pp. 72, pls. 10. 1899.

[c] Orton, W. A. The Wilt Disease of Cotton and Its Control. Bul. 27, Div. Veg. Phys. and Path., U. S. Dept. Agriculture. 1900.

[d] Smith, R. I., and Lewis, A. C. "Black Root" Disease of Cotton. Bul. 22, Georgia State Board of Entomology. 1906.

[e] Fulton, H. R. Cotton Wilt. Bul. 96, Louisiana Agricultural Experiment Station. 1907.

GEOGRAPHICAL DISTRIBUTION OF WILT.

Cotton wilt is widely distributed over the cotton belt, especi the sandy soils of the Coastal Plain. It occurs to a slight ext eastern North Carolina and is found to be more common a travels southward to Florida and westward to southeastern Ala From there to eastern Texas it diminishes somewhat in preva

The accompanying map (fig. 1) shows these facts graphi Each dot marks a locality where wilt is known to occur. Th tribution of the disease is without doubt wider than here s Attention is called to the relation between geological and soil f and the occurrence of wilt as indicated by the line which approximately the boundary of the Coastal Plain. Most of the

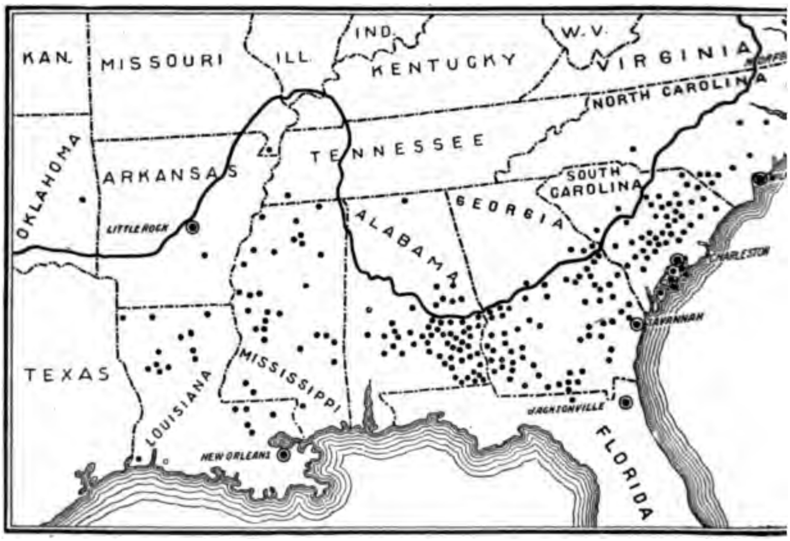

FIG. 1.—Map of the southeastern United States, showing the geographical distribution of

try south and east of this line is level, with sandy soils of al origin, and was originally covered with pine forests. Here most prevalent. The country north and west of this line is the mont Plateau, consisting of rolling hills, with clay soils predomin and formerly covered with oak and other deciduous trees. quite rare in this section, occurring mainly on scattered are sandy and alluvial soils. Undoubted cases of wilt have been in Tennessee, Arkansas, Missouri, and Oklahoma, however, and is little doubt that the disease can develop in any congenial soil Mississippi it appears to be more prevalent along the eastern of the Yazoo Delta than elsewhere.

Cotton wilt is not present on all the farms in any of the com ties mentioned. In some cases only a small percentage of the l infected, but the diseased areas are steadily enlarging.

Occurrence of wilt in foreign countries.—Cases of what was thought to be this disease have been reported from Egypt and other parts of Africa, and from Turkestan in Asia. The identification of these troubles as the American wilt has not yet been definitely settled.

AMOUNT OF LOSS FROM WILT.

It is very difficult to estimate the total loss from cotton wilt. The injury varies from the death of a few plants to the destruction of hundreds of acres. Several factors are to be considered in estimating the loss. We must add to the actual shortage of the crop in the spots where the cotton dies: (1) A diminished yield of the surrounding cotton due to the dwarfing of the plants from partial infections; (2) a lessened income to the farmers on account of the necessity of planting on infected land some less profitable crop, such as corn, or of throwing cotton out of cultivation altogether; (3) the increased cost of cultivation of wilt-infected spots due to the foothold obtained by crab-grass, nut-grass, cockleburs, and other weeds, after the death of the cotton; (4) a depreciation in the market value of wilt-infected land.

These losses probably amount to more than $2,000,000 per annum and are annually increasing.

DESCRIPTION OF WILT.

FIELD CHARACTERS.

Cotton wilt may make its appearance on single plants in a field, but its later and most characteristic development is in definite spots of irregular size and varying area in which most of the plants slowly wilt and die. Some plants partially recover, but remain dwarfed and bushy, often one sided, while for some distance around the wilt-infected area the cotton is more or less stunted by partial root infections. Occasional plants are found to remain healthy even in the worst infected spots. Of two plants in the same hill one may die and the other live.

The disease reappears in the same place each year cotton is planted and on a larger scale. This annual appearance and spread will distinguish wilt from barren spots due to other causes, such as poor soil, shell banks, lightning, etc.

Wilt first appears in the latter part of May or in June, when the young cotton is 8 to 12 inches high. It is most prevalent during June and July, but some cases continue to develop until the end of the season.

PLANT SYMPTOMS.

The appearance of a cotton plant attacked by wilt varies somewhat, depending on the age of the plant and the severity of the attack (see fig. 2). Some plants wilt suddenly and die almost in a day; others pass through intermediate stages, with leaves slowly turning yellow, especially around the margins and between the veins, and fall off. Often a branch near the ground makes considerable growth and partially recovers, producing a dwarf, bushy plant.

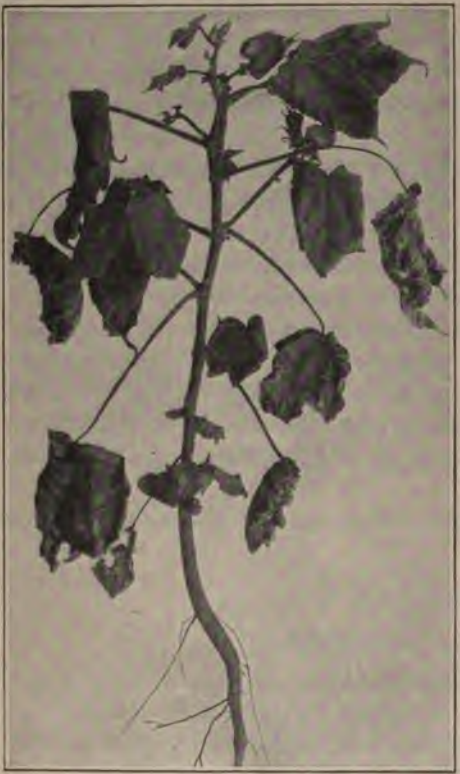

FIG. 2.—A young cotton plant dying from wilt

The roots of diseased plants are shorter than those of healthy plants, many rootlets dying back from the tips, and there is a characteristic tufting of the small rootlets due to repeated partial infection by the wilt fungus.

The most characteristic symptom of wilt is a browning of the woody portion of the stem and root as seen in the cross sections illustrated in figure 3. These discolored parts are the water-carrying vessels which have become obstructed by the development in them of the fungus causing the disease. A highly magnified section of a segment from the pith to the bark in such a stem is shown in figure 4. The network of colorless threads filling these vessels is the mycelium of the wilt fungus, which has thus cut off the water supply and killed the plant.

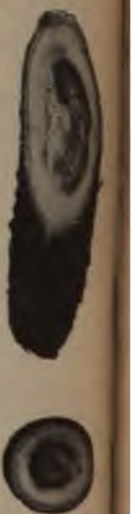

FIG. 3.—Cross sections of cotton stem, showing browning of wood caused by the wilt fungus. (Natural size.)

THE WILT FUNGUS.

Life history.—The wilt fungus[a] is itself a low form of plant life which has adapted itself to existence as a parasite. In its vegetative form it consists of the mycelium illustrated in figure 5, *b*, which is made up of slender threads of microscopic size. It lives in the earth on decaying organic matter until it encounters the small feeding roots of the cotton, which it enters. This fungus is fully able to penetrate healthy roots. Wounds or root-knot injuries are not necessary to infection, though plants weakened by root-knot may succumb more quickly to wilt. The fungus penetrates the vascular system of the root and grows upward into the stem. During the life of the host plant the fungus is mainly confined to the vessels.

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[a] *Neocosmospora vasinfecta* (Atk.) Erw. Sm.

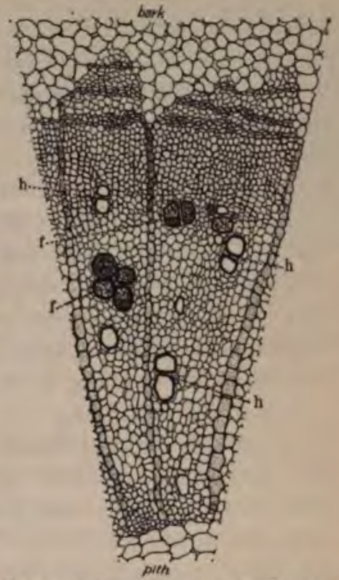

FIG. 4.—Enlarged section of part of a diseased cotton stem, showing vessels filled by the wilt fungus. Normal water vessels are shown (h) in comparison with several such vessels (f) plugged by the wilt fungus.

iberal provision is made for the reproduction and spread of this fungus through four different spore forms, also illustrated in figure 5. The first, or microconidia (*b*), are small, colorless spores borne on the mycelium within the vessels. The second, or macroconidia (*a*), are larger, sickle-shaped, or Fusarium spores and are borne in great numbers on oblong pink cushions on the outer bark of the stem after the plant dies and the fungus grows outward from the vessels. These two spore forms are short lived, but serve to spread the fungus widely under favorable conditions. The third form, or chlamydospore (*c*), is produced on the outside of the plant, mainly in the soil. It is thick walled and withstands drying or other unfavorable conditions. The fourth is a perfect stage, or ascospore (*e*). These ascospores are developed in sacs, or asci, within bright red, pear-shaped perithecia (*d*) on the bark of decaying cotton roots. Although visible to the unaided eye as red bodies the size of sand grains, these perithecia are difficult to find in the field, as they are not abundant except at a certain stage in the decay of the root.

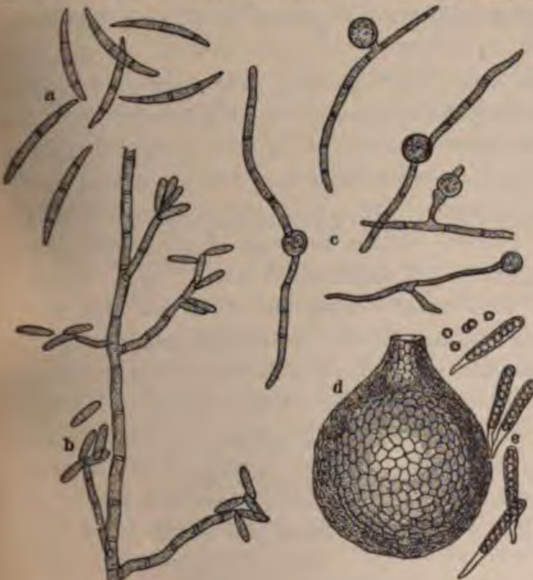

FIG. 5.—The cotton-wilt fungus. *a*, Macroconidia of fusarium stage from outer bark of dead stem; *b*, hyphæ and microconidia from vessels of freshly wilted stem; *c*, chlamydospores from bark of root; *d*, bright red perithecia from root of dead plant; *e*, asci and ascospores borne in the perithecia.

Relationship to other fungi.—The cotton wilt fungus attacks okra, which is botanically related to cotton, but it is not known to be parasitic on any other plant.

Very similar and closely related fungi produce wilt diseases of numerous crops, as first pointed out by Dr. Erwin F. Smith, of the Bureau of Plant Industry. The cowpea wilt is of the same type. It is this disease which makes it impossible to grow peas on certain fields, which the farmer calls "peasick." One variety, the Iron cowpea, is immune to this disease and can be grown on infected land.

Watermelon wilt is also prevalent in the South to such an extent that commercial growers never plant melons after melons until ten or more years have elapsed. The Bureau of Plant Industry has just succeeded in breeding a variety resistant to this disease.

The fungi producing cowpea and melon wilt are indistinguishable from the cotton wilt fungus except by inoculation tests. They are not parasitic on cotton. This is an important point in connection with the subject of crop rotation. There is no evidence that other crops or weeds carry infection to cotton except through increasing root-knot, as discussed later in this bulletin.

Manner of spread.—The original source of infection in most communities is unknown. Once introduced, the disease spreads in several ways:

(1) *By direct growth through the soil.* The infected areas enlarge each year, in some cases several rods in a season. There appears to be no practicable method of checking such spread by ditches, furrows, or other barriers.

(2) *On cultivators, plows, etc.* Any agency that will carry soil, parts of plants, etc., containing the fungus spores will serve to spread the disease. Instances have been observed where the wilt had apparently been distributed through a field in this way, and it would seem desirable where a corner of a field is infected to throw it out of cultivation rather than drive across it. Other preventive measures, such as the disinfection of tools, are impracticable.

(3) *By drainage water.* The surface drainage of an infected field will carry the wilt to lower land. There is special danger in the overflow during heavy rains, and it will be worth while in many cases to make ditches or terraces to divert such drainage water.

(4) *On the feet of cattle.* Just as plows may spread the wilt, so may stock pastured in an old cotton field carry it to healthy fields through which they pass. Cases of this sort have been observed where the first appearance of wilt was along the paths the cattle had been accustomed to follow.

(5) *In stable manure and compost.* If diseased plants find their way to the stable the fungus will develop in the manure and be carried wherever it is put. This is very likely to happen with the water-

melon wilt through vines brought in with hay from melon fields, but the danger is less with cotton. Far too little stable manure is produced and used on a cotton plantation, but if there is any evidence that manure is spreading the wilt it would be better to use it on that portion of the farm already infected. The resistant varieties of cotton are greatly benefited by it.

(6) *By seed from infected fields.* There is no proof that wilt is spread by seed from infected fields. The fungus is not known to penetrate the seed coats. The only way seed could be infected is by contact with diseased plants covered with spores. If this were feared all danger could be avoided by soaking the seed in formalin—8 ounces to 15 gallons of water—for ten minutes, then drying thoroughly at once.

Rate of spread.—The rate of spread varies according to the conditions. In one case that has been under observation for several years and may be cited as typical, the infected area on one farm grew from 5 acres to 60 acres in five years. Cotton wilt spreads slowly in comparison with diseases like asparagus rust and cucumber mildew, which travel hundreds of miles in a season, but its infection of the soil is permanent.

INFLUENCE OF SEASONAL CONDITIONS ON WILT.

Wilt is worse on the whole in wet seasons. Conditions that lead to a rapid growth of the cotton plant also favor the development of its parasite. It has often been remarked that fresh cases of wilt were most numerous just after a rain or a cultivation.

Seasonal conditions do not influence wilt to such an extent as to permit hope that the disease will fail to appear the next season after it has once become established.

INFLUENCE OF TIME OF PLANTING ON WILT.

The time of planting the cotton crop does not bear any marked relation to the prevalence of wilt. Some farmers have thought that late-planted cotton suffered less, but these instances were due to a fortunate combination of weather conditions. Repeated tests have shown that it is useless to defer planting in the hope of escaping wilt. As a rule early planting gives the best crop.

INFLUENCE OF SOIL CONDITIONS ON WILT.

Cotton wilt occurs mainly in sandy soils or in those containing a large proportion of sand. It is frequently met with in fields having a clay subsoil where the topsoil is sandy, and more rarely in soils containing considerable clay which border infected sandy fields. It is not to be feared, however, in ordinary upland clay or clay loam soils.

Wilt is perhaps worse in thin soils than those rich in organic matter, but it does occur in rich and highly manured land, often to a very serious extent. Efforts to remedy the trouble by green manuring usually result in a great increase of the disease, but this is ordinarily due to the fact that varieties of cowpeas susceptible to root-knot are grown for plowing under. The writer has not seen the wilt on black prairie soils.

Wilt is less injurious to cotton on low land or in low spots in a field. These are richer in organic matter and are also wetter; probably both factors are involved.

INFLUENCE OF FERTILIZERS ON WILT.

It must be borne in mind that wilt is due to an active plant parasite which has no fixed connection with any farm practices in the use of fertilizers.

No reliable evidence can be brought forward to show that the disease is caused, as believed by many farmers, by the continual use of commercial fertilizer, by the use of acid phosphate, or even by continual cropping in cotton. Neither is it true that wilt is due to the absence of some element in soil fertility, such as lime, potash, or magnesium. It is due simply to the presence of the cotton-wilt fungus, the specific parasite causing the disease. This fungus plant may be viewed as a troublesome weed, and, like weeds of large size, it is likely to develop wherever its spores (the reproductive organs) are carried. If susceptible cotton plants are growing there, the cotton will become diseased.

Differences between fields have been noted by farmers and attributed to fertilizers which are rather due to changes in soil conditions. The application of stable manure has been recommended as a remedy for wilt. Our experience has been that in slightly infected fields this does give some relief, but that the wilt takes the field in the end in spite of the heaviest manuring. The use of stable manure in growing resistant varieties of cotton has been very profitable, however.

It has been positively shown that modifications of the fertilizer formula will not assist in the control of wilt. The use of acid phosphate, muriate of potash, etc., it is true, renders the soil acid, but this does not especially favor the wilt disease, for both infected and healthy fields are alike in this respect, and applications of lime to infected land at the rate of from 2 to 6 tons per acre have been made without reducing the amount of wilt. The disease also occurs on newly cleared land and in old fields that have never had any commercial fertilizer. Kainit, so valuable as a preventive of rust on cotton, has no influence on wilt. Applications of quantities amounting to 2,000 and 4,000 pounds to the acre have proved as ineffective as smaller amounts.

INFLUENCE OF FUNGICIDES ON WILT.

Soil from an infected field contains the wilt fungus, and cotton planted in it will contract the disease. If, however, such soil were sterilized by heat or by the use of chemicals, healthy cotton could again be grown. The effective sterilization of soil under field conditions presents many difficulties and has never yet been accomplished except at prohibitive cost.

In the experiments of the Bureau of Plant Industry with cotton wilt a large number of fungicides, including sulphur, copper sulphate, copper carbonate, copper acetate, Bordeaux mixture, lime and sulphur, liver of sulphur, iron sulphate, carbolic acid, and formalin were applied to wilt-infected soils in such liberal quantities that the cost of the treatment exceeded the value of the land, but in no case was the amount of wilt lessened.

It is not believed that any treatment of this sort is practicable.

INFLUENCE OF ROTATION OF CROPS ON WILT.

While the cotton-wilt fungus is not known to attack other plants, except okra, and would therefore not be likely to be carried over on other crops or on weeds, it can live as a saprophyte, feeding on decaying organic matter in the soil, for a long time, and short rotations are of little use in reducing wilt. Experience with rotations of seven to ten years has shown that the amount of wilt gradually diminishes, but no case is known where land has been entirely freed from the disease in this way.

The subject of rotation is so much more important in connection with the control of root-knot that it is treated more fully elsewhere in this paper.

RESISTANCE TO WILT.

The standard varieties of cotton differ considerably in susceptibility to wilt, but none of them are sufficiently resistant to be cultivated with profit on infected land. Extended variety tests on infected fields have shown that as a general rule the large-boll sorts, Russell, Truitt, etc., are more subject to wilt than other groups of varieties. The most resistant of the American Upland varieties tested was the Jackson Limbless, which produced about 45 per cent of a crop where other kinds failed. The original Jackson was not sufficiently resistant to justify its general cultivation, but it has been of value as a basis for breeding better races.

Egyptian cotton is more resistant to wilt than Upland cotton, but it has not as yet been found practicable to utilize this quality, as the Egyptian varieties do not succeed in our Southeastern States and it is easier to breed resistance direct from Upland varieties than crosses with Egyptian cotton.

Differences in resistance within varieties are quite conspicuous. Observation of infected fields will show that all plants are not equally affected. Frequently two plants may be found in the same hill, one wilted, the other healthy, and even in the most severely infected spots there may occasionally be found a plant apparently resistant. In many cases these differences are due to noninfection or other temporary causes, as seed selected from such plants often proves nonresistant the next season.

RESULTS OF EXPERIMENTS IN BREEDING FOR WILT RESISTANCE.

The individual differences in cotton plants have been utilized as a basis for breeding new resistant strains. The work of the Bureau of Plant Industry has now been continued along this line for eight years, and has resulted in the successful development of two new varieties that can be grown on the worst infected land, provided a rotation of crops for the control of root-knot is practiced.

The use of resistant varieties has been shown by experiments in all the States from North Carolina to Louisiana to be a satisfactory method of combating wilt. The Bureau of Plant Industry has also shown the probability that continued breeding will result in the development of other improved strains possibly better adapted to the requirements of the section where they originate than any existing kinds.

The development of such varieties, however, is neither quickly nor easily accomplished, but requires breeding by exact methods for several years. It will not suffice to send pickers through the fields to gather seed cotton from apparently resistant plants, as some have recommended. Our experience has been that such mass selection is expensive and ineffective. Much of the seed obtained is taken from plants not truly resistant, and the succeeding crop is nearly as much diseased as the first. While such a method should result in increasing the resistance of the crop in the long run, the cross-pollination between resistant and nonresistant plants greatly delays the results. The correct method is to select with great care a small number of plants that appear to be healthy, though growing in the worst infected areas. The seed from each of these plants must be kept separate and planted in parallel rows on infected land the next year. The resulting progeny will show which of the plants selected transmits the resistant quality in the most effective manner. The rows will also vary much in productiveness and other qualities. The best one should be selected and the others discarded. In some cases a resistant row of satisfactory quality has been found the first year, and only two more seasons were required to multiply the seed, but more often complete success has not been had at once and the work had to be repeated.

origination of new wilt-resistant varieties is work for the plant
er rather than the general farmer, and there is need for men in
county to take up the business of breeding to supply this
nd. The farmer, however, should practice selection to further
ve the strain purchased from breeders, or at least to preserve
m deterioration. The Bureau of Plant Industry desires to
late the breeding and sale of improved varieties of cotton. To
nd it will place the varieties already developed in the hands of
vho will improve them and offer them for sale.

DESCRIPTION OF RESISTANT VARIETIES.

on.—The first of the wilt-resistant varieties to be sent out
een named Dillon from the fact that the original selections
made in Dillon, S. C., in 1900. From 1902 to 1904 it was
at Troy, Ala., in 1905 and 1906 at Notasulga, Ala., and dur-
07 and 1908 at Lamar, S. C.

parent variety was Jackson Limbless, a cotton greatly over-
ited at the time of its introduction and not widely grown at
resent time. The first variety test showed the Jackson to be
more resistant than other races of cotton, and this quality has
greatly intensified by subsequent breeding. Preliminary dis-
ions were made in 1905, 1906, and 1907, when small quantities
d were sent out under the name "Wilt-Resistant Jackson" for
imental trials. It was found that this name led to confusion
the unselected original Jackson and that the new strain differed
the original in being more resistant, productive, and uniform,
o some degree in having bolls less closely clustered and easier
k, seed of darker color, etc. For these reasons the improved
sent out in 1908 has been named Dillon. A technical descrip-
ollows:

t tall, erect, wilt resistant, productive, often with one, two, or three large
ranches. Fruiting limbs reduced to clusters of bolls close to the main stalk.
medium size; bolls of medium size, 80 being required to yield 1 pound of
otton. Bolls erect, seed small, average weight of 100 seeds 9 grams, covered
ose, brownish green fuzz. Staple medium to short, ⅞ to 1 inch, white, straight,
tage of lint to seed cotton 37.

group of Upland varieties having clustered bolls is not very
ar among farmers, some being unduly prejudiced against it.
rt, however, this feeling is accounted for by the fact that the
n is harder to pick than big-boll varieties. This difficulty in
g is counterbalanced in part by the stormproof quality, as Dil-
as held all its cotton through storms that have blown to the
d all cotton open on other varieties. Greater objections are
on this score in sections where big-boll varieties are grown
where the prevailing kinds are of the King or Peterkin groups.

Further objection is also made to the cluster varieties because the cotton is more trashy after storms, due to fragments of the involucre adhering to the lint.

Breeders should seek to select easy-picking strains of Dillon. The bolls should also be bred to have separate pedicels, thus opening the clusters. Those who object to its faults should not lose sight of the fact that even on land not infected by wilt Dillon has been proved to rank high in productiveness, and on infected land it will yield many times as much as nonresistant kinds. A field in South Carolina where cotton had previously been a complete failure from wilt, even when highly fertilized and intensively cultivated, yielded 1½ bales per acre of Dillon cotton in 1907. (See figs. 6, 7, and 8.)

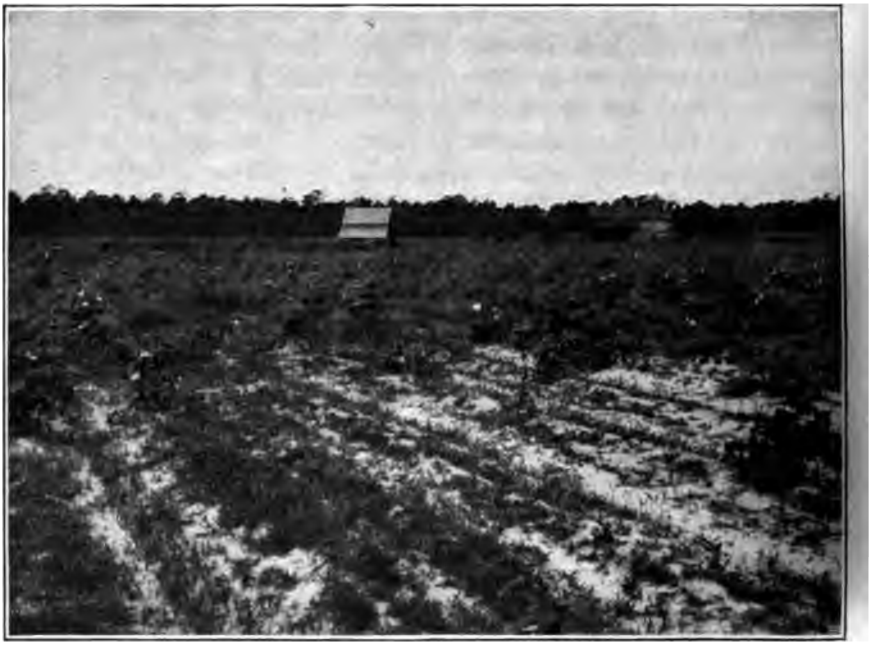

FIG. 6.—Field of Upland cotton in South Carolina destroyed by wilt.

The Dillon variety appears to succeed best in the northern portion of the cotton belt, including North Carolina, South Carolina, and parts of Georgia. The southern and western portions may obtain better results from Dixie.

Dixie.—The Dixie variety is described as follows:

> Plant vigorous, wilt resistant, nearly of the Peterkin type, pyramidal, with large basal branches and long, slender fruiting limbs; leaves medium size; bolls medium, 70 required for 1 pound of seed cotton, easy to pick; seed small, weight of 100 seeds 10 grams, variable in color but typically covered with greenish brown fuzz; lint 1 to 1⅛ inch, percentage of lint to seed 34. (See fig. 9.)

he Dixie variety had its origin in a selection made at Troy, Ala., plant presumably the result of an accidental cross between two ie numerous Upland varieties planted there in 1902. It has been l by the progeny row method until well fixed, but should be given her selection to increase the size of bolls and general productive- . It has proved an excellent variety in several tests in Alabama Georgia and will in the end be more widely grown than the on cotton.

a Island cotton.—Before the above-described Upland varieties on and Dixie) had been perfected, the problem was taken rith Sea Island cotton where the conditions with reference to tance are much the same as with Upland cotton. Several resist-

7.—Wilt-resistant Dillon cotton growing on land adjoining that shown in figure 6 and even worse infected with wilt.

strains of Sea Island cotton have been developed and are now in cessful cultivation. Further details of this work are given in rmers' Bulletin No. 302,[a] which will be sent free of charge on plication to the Secretary of Agriculture.

FURTHER IMPROVEMENTS IN COTTON VARIETIES NEEDED.

There still remain many problems in connection with the breeding wilt-resistant cotton, and it is desirable that many breeders engage the work of producing Upland strains. The principal aims to be kept in mind are earliness, larger bolls, and adaptation to pai localities.

---

[a] Orton, W. A. Sea Island Cotton: Its Culture, Improvement, and Diseases. rmers' Bulletin 302, U. S. Dept. Agriculture. 1907.

Total immunity to wilt has not been secured in any case. sional plants become diseased in the best fields, but no seric results if selection is maintained. It is not expected that the re varieties bred by the Bureau of Plant Industry will maintai resistance indefinitely unless seed selection is practiced.

In view of the threatened early invasion of the eastern cottor by the boll weevil it is important that breeders should set abo ducing early large-boll of wilt-resisting cottor indications are that the Dillon nor the Di riety is early enough meet the requirements ton culture in the pres the boll weevil. A is needed which combi wilt resistance of the variety with the larg earliness, and product of the Triumph cott which is adapted to conditions, a feature ently lacking in the T variety.

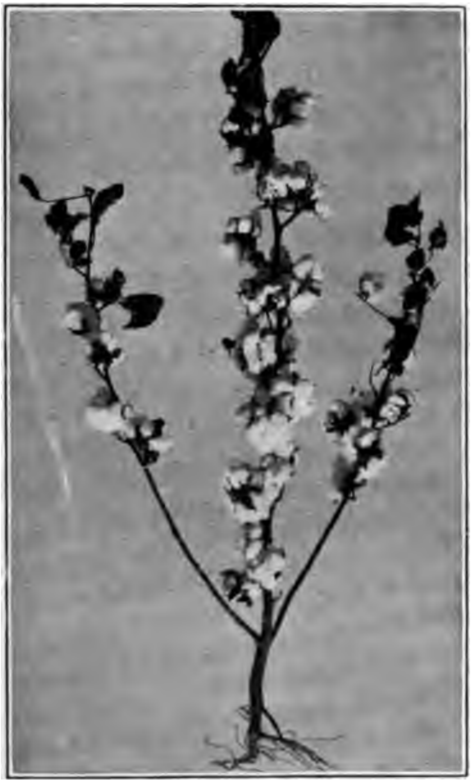

FIG. 8.—Typical plant of Dillon wilt-resistant cotton.

ROOT-KNOT IN REI TO WILT.

Root-knot is a d caused by an eelwc nematode (*Heterodera cola* (Greef.) Mül.). parasite, which is ver from one-twentieth sixtieth of an inch long, penetrates the roots and by the ir of its presence causes the formation of irregular swellings o varying in size from very minute enlargements of the small r knots an inch or more thick. In these swellings the woi numerous eggs, which soon develop. Several generations oc single season.

The affected plants are dwarfed. In some cases they die o while in others the presence of root-knot is not suspected u roots are examined.

reat many varieties of cultivated plants and weeds are attacked ot-knot, nearly 400 species being already known to be suscepti- it. These may be very liable to injury, as is the case with , tomatoes, okra, cucumbers, and cowpeas, or relatively resist- s with sugar cane and sweet potato.[a]

ton is moderately subject to root-knot and is so affected as to lerably reduce the yields in hundreds of fields whose owners are unt of its presence. The plant illustrated in figure 10 shows a d severe case of not. If such become in- l with wilt, how- the two dis- combined will ilate the crop. e wilt-resistant ties bred by the rtment are not ly resistant to knot. It is not able to plant on infested land it has first been a rotation of or preferably , years in crops ubject to root- , and in all cases oot-knot factor ld be considered nning rotations ndy fields.

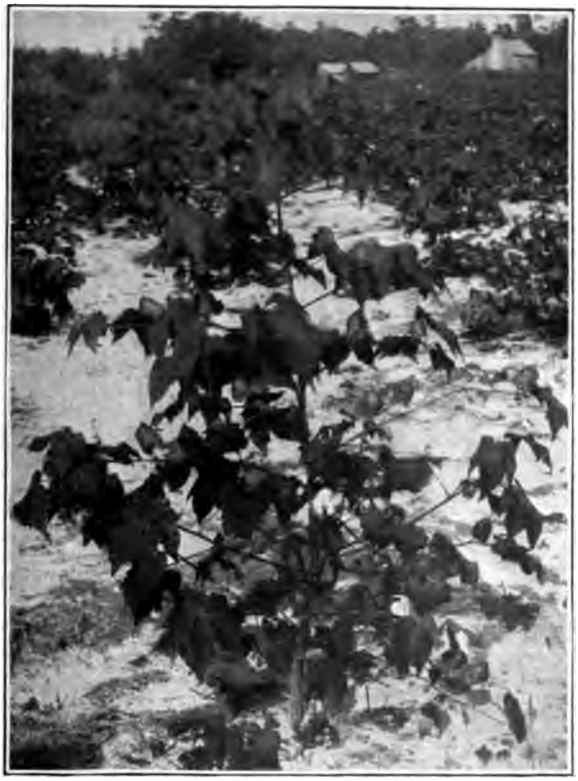

FIG. 9.—Typical plant of Dixie wilt-resistant cotton.

all cases in- gated where the resistant cotton out by the Bureau of Plant Industry was reported to have l, the reason was found to be root-knot.

ot-knot is much like the wilt fungus in its soil relations, pre- g sandy soils and never becoming troublesome in heavier or wet or clay loams. It is very common throughout the South and be taken into account in every plan for the control of wilt.

---

[a] thorough investigation of root-knot is being made by Dr. Ernst A. Bessey, of ureau of Plant Industry.

The principal agency in bringing about this general prevalence of root-knot in the South has been the use of cowpeas for soil improvement. The cowpea is quite subject to this parasite. The worms multiply rapidly in the roots, and each succeeding crop of peas leaves the ground in worse condition. Many farmers have already discovered this connection between the cowpea crop and their cotton disease without knowing the reason and have also observed that winter oats are beneficial, which is because they do not harbor the root-knot parasite.

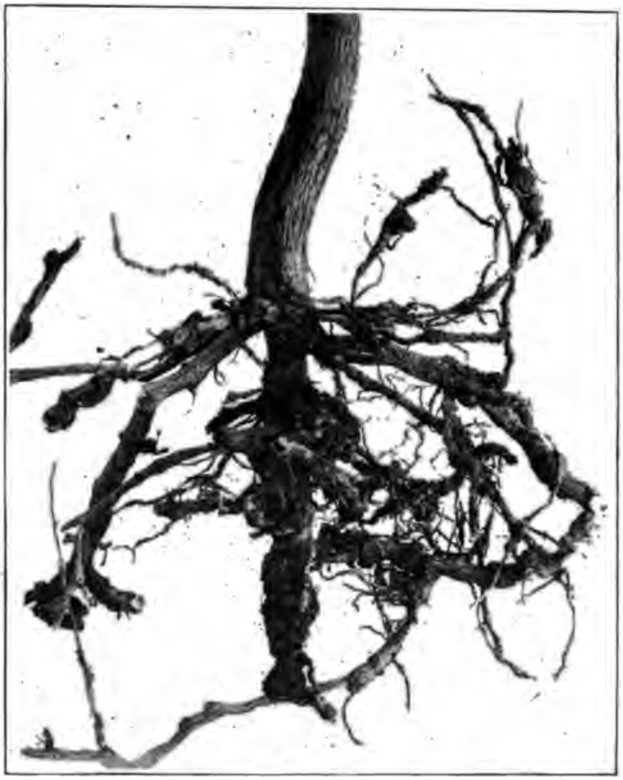

FIG. 10.—Root-knot on cotton plant. Cowpeas were grown the year before on the land on which this plant was grown.

All the common varieties of cowpeas, including the speckled or Whippoorwill, Unknown, Black, Clay, and New Era, are subject to root-knot and should be avoided throughout the territory shown in the map (fig. 1) to be liable to the wilt. This can be done without serious difficulty by the substitution of the Iron cowpea, a variety resistant to root-knot and wilt, and by the increased use of velvet beans, peanuts, and beggarweed for forage crops. New resistant cowpeas produced by hybridizing the Iron with other varieties are being developed by the Bureau of Plant Industry.

ROTATIONS OF CROPS FOR CONTROLLING ROOT-KNOT.

A rotation of crops must be worked out in detail for each farm to t its particular needs. The essential principles to be observed are s follows:

(1) To use crops immune to root-knot, in order to starve out the est.

(2) To build up the fertility of the soil, and especially to increase he amount of organic matter, or humus.

(3) To secure an adequate income during each year of the rotation.

(4) To keep the land free from weeds that are liable to root-knot.

A list[a] of the crops not liable to root-knot which can be used in such rotations follows: Corn, winter oats, rye, wheat, crab-grass, Iron cowpea, velvet bean, peanut, beggarweed.

Some of the crops susceptible to nematodes, and therefore to be avoided in rotations for root-knot, are cowpeas (except Iron), alfalfa, vetch, soy beans, clover, sugar cane, tomatoes, okra, cucumbers, cantaloupes, watermelons, celery, beans, sweet potato, tobacco, potato, peaches, figs, mulberry. The Iron cowpea is occasionally slightly affected in Florida, but is practically immune in the cotton belt. Seed of the Iron cowpea containing admixtures of other kinds is dangerous and should be avoided.

Bermuda grass, chufas, and summer oats are slightly susceptible, but probably can be used in rotation when root-knot is only slightly prevalent. Many weeds are also to be avoided because subject to root-knot. The commoner of these are "May-pop," "Indian potato," "saw-brier," red-root or pigweed (Amaranthus), and purslane.

The following treatment is suggested for fields infected with both wilt and root-knot:

Beginning in the fall, sow winter oats. These may be cut for hay in May or allowed to ripen. Follow the oats with Iron cowpeas, sown broadcast or, better, in drills, where they can be cultivated once or twice. Cut these peas for hay and plow the land at once for another crop of winter grain. This may be succeeded by corn, with Iron cowpeas or peanuts between the rows. The third year a wilt-resistant variety of cotton may be planted.

Wheat or rye may be substituted for oats, and the velvet bean for he Iron cowpea, especially in the more southern districts.

Considerable relief is often obtained by a single year's rotation with ats followed by crab-grass, or winter oats or rye followed by Iron owpeas, but not all the nematodes are destroyed. However, it is nuch more profitable in the long run to practice a three-year rotation ike that previously described.

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[a] Prepared with the assistance of Dr. Ernst A. Be[illegible]

BREEDING METHODS.

It will rarely be profitable for a farmer to attempt to develop a new wilt-resistant strain from a nonresistant variety, for the reason that several years of careful selection are required. A better way would be to begin with a resistant variety that the Bureau of Plant Industry has developed and modify it by further selection or cross it with a cotton possessing the desired characters. Cotton breeding will in the future be a prominent feature of the work of the Department of Agriculture and of the agricultural experiment stations, and the grower may look to them to perform the painstaking work of originating new kinds. The growers must, however, expect to continue the selection process, not only to keep the strains from mixing or deteriorating, but also to further improve them.

UNSYSTEMATIC BREEDING METHODS UNPROFITABLE.

Enough of the principles underlying plant breeding have now been discovered to show that certain methods will give the quickest and best results, and that neglect of these principles is like working in the dark and equally uncertain of accomplishing the desired aim.

Mass selection.—For example, some have advised that farmers develop a resistant variety by saving their seed by mass selection from infected fields and planting it in the same place the following year, continuing the process until the cotton became resistant. As a matter of fact, such a method would never pay or give results except by accident. The real secret of success lies in selection from individual plants and a judicious choice of the best of their offspring.

Mass selection, however, is the most common method employed by cotton planters at the present time, and consists in picking from the best plants enough seed cotton to yield, when ginned, sufficient seed for planting the next year's crop.

This is better than no selection, but will not yield the best results in the shortest time. The cotton plants in an ordinary field differ greatly in form of plant, size of boll, productiveness, and other qualities. Mass selection involves the mixing of seed from numerous diverse plants, and results in lack of uniformity in the following crop. More important still, it has been found that cotton plants differ greatly in their ability to transmit their good qualities, and mass selection does not permit the separation of plants breeding true to type from those with highly variable offspring.

The most accurate and effective method of improving a strain of cotton is by breeding from single plants of exceptional merit and proved transmitting power, i. e., pedigree breeding.

SYSTEMATIC BREEDING METHODS.

A discussion of the methods of breeding will fall into two parts:) How to keep pure a strain already on hand, and (2) how to im- :ove or develop new strains.

Roguing.—The first aim is accomplished by roguing, or the re- ioval of plants. A farmer who has secured from the Bureau of 'lant Industry or elsewhere a stock of resistant seed should go hrough his field at least twice, when the first blossoms appear and ust before the first picking, to remove all plants showing wilt and ll which differ from the type of the variety. For example, in a ield of the Dillon variety all plants with a different type of branching should be pulled out, even though they should be resistant and productive, for our experience has been that a large part of the offspring of such plants is nonresistant. After these undesirable plants have been removed all the rest may be used for seed, except the last picking, the seed from which is likely to be immature.

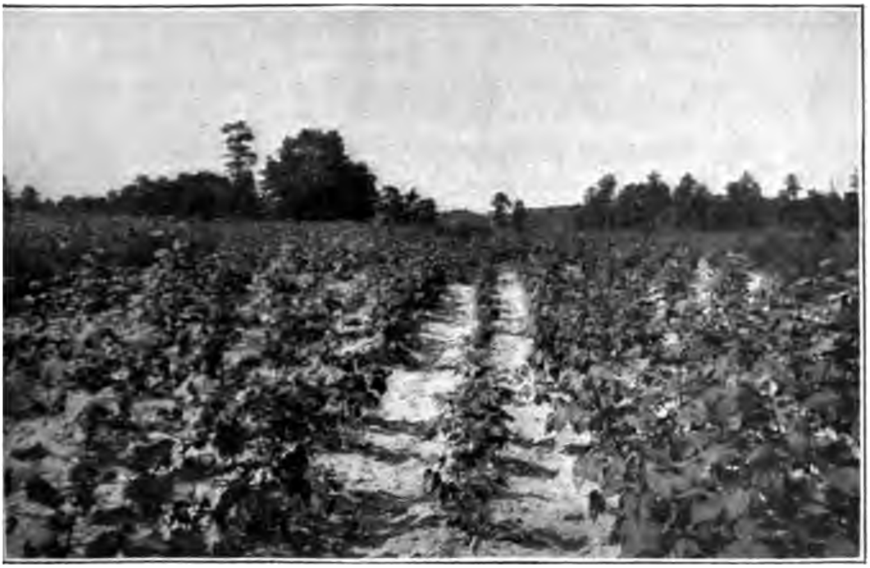

FIG. 11.—Progeny rows in breeding plots of the Bureau of Plant Industry. Each row is planted with seed from a single plant; the center row is from a nonresistant parent plant

Pedigree breeding.—The initial step in pedigree breeding is the choice of a considerable number of exceptionally fine plants from the general field. Consideration is given to the qualities of wilt resistance, productiveness, earliness, form, size of bolls, etc. Selected plants are marked with a white cloth and picked separately. After the last picking, a critical examination should be given the seed cotton and the total yield of each plant determined; also, the length and [illegible] staple, the percentage of lint to seed,[a] and the weight of 100 s At this time some of the more inferior lots may be discarded an total number reduced to 25 or 50.

The next year the selected individual lots are to be planted rately in parallel rows of 50 or 100 hills at uniform distances. is important to secure a full stand, a portion of the seed shou retained for replanting.

This progeny test is the most important feature of the plan. M differences may be observed in the several rows (see fig. 11). row should be picked separately to determine its yield and shou examined critically with reference to its other characters. Th row may then be selected and the seed multiplied as rapidly as po for general planting.

A new progeny plot should be planted each year. Many o individual selections will naturally be made from the progeny of the preceding year, but some should be made from the ge field in the hope of securing improvements and to bring in ' blood."

METHODS OF DISTRIBUTING SEED.

The question of distributing wilt-resistant seed in such a way all sections may receive benefit from the work of the Bureau of I Industry is an important one. It is evidently out of the que for the Department of Agriculture to send seed to all who need sufficient quantity to plant their crops. The only solution of difficulty is to encourage local breeders to grow and offer see sale.

To this end the Department of Agriculture has begun to send seed to men who have been ascertained by previous correspond to have wilt-infected land and to be willing to care for the s The quantity given to each is one-half bushel, enough so th planted with care at least a bale of cotton can be raised; then cotton can be taken to the gin and the seed saved free from mix with other kinds.

Those receiving this wilt-resistant seed are expected to heed advice given in this bulletin to keep the seed pure and sell to t neighbors. At the present time this wilt-resistant cotton is inclu in the Congressional distribution of seeds by the Department Agriculture, so that farmers desiring to obtain it should make ap cation through their Member of Congress. The quantity avail for each Congressional district will be quite limited.

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[a] Consult Circular No. 11, Bureau of Plant Industry, U. S. Dept. Agriculture titled "Danger in Judging Cotton Varieties by Lint Percentages," by O. F. C 1908.

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Issued October 3, 1908.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 334.

xperiment Station Work,

XLVIII.

Compiled from the Publications of the Agricultural Experiment Stations.

BREEDING ON THE FARM.
UM FOR SILAGE.
OT OF CORN.
H FROM SWEET POTATOES.
TS FROM TOMATO GROWING.
EEPING OF APPLES.
SEEDS IN MANURE.
SEEDS IN FEEDING STUFFS.
FORAGE CROPS FOR PIGS.
MARKET CLASSES AND GRADES OF HORSES AND MULES.
PROFITABLE AND UNPROFITABLE COWS.
BLACKHEAD IN TURKEYS.
EXTRACTION OF BEESWAX.
AN IMPROVED HOG COT.

JULY, 1908.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

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1908.

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[a] Director.

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XPERIMENT STATION WORK.

ited by W. H. Beal and the Staff of the Experiment Station Record.

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ment Station Work is a subseries of brief popular bulletins compiled from
shed reports of the agricultural experiment stations and kindred institutions
d other countries. The chief object of these publications is to disseminate
t the country information regarding experiments at the different experi-
ions, and thus to acquaint farmers in a general way with the progress of
al investigation on its practical side. The results herein reported should
ost part be regarded as tentative and suggestive rather than conclusive.
xperiments may modify them, and experience alone can show how far they
seful in actual practice. The work of the stations must not be depended
roduce "rules for farming." How to apply the results of experiments to
onditions will ever remain the problem of the individual farmer.—A. C.
rector, Office of Experiment Stations.

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EXPERIMENT STATION WORK.[a]

PLANT BREEDING ON THE FARM.[b]

Much greater and more rapid progress in the improvement of farm
ps would be possible if in general more careful attention were
en on the farm to the methods of seed selection and plant breed-
g. If, for instance, as much time, thought, and effort were devoted
the matter of crop improvement as are given to the bettering of
ltural methods and practices the general results would soon force
emselves into prominence and a much greater benefit from the
rk and discoveries of our specialists and scientists would be real-
d. Dr. H. J. Webber, of the Cornell Station, calls attention to
is fact in a recent bulletin and discusses simple methods of plant
eeding suitable for the general use of farmers. The crops con-
lered include corn, but the methods of corn breeding have been so
ly discussed in previous bulletins that no further account is taken
re of this subject.[c] The field selection of seed is also discussed in
revious bulletin of this series.[d]

ertain lines of wheat improvement, particularly those to increase
yield and to better adapt the crop to local conditions, are con-
ered simple enough for any intelligent grower, but methods of
d improvement are seldom found in use. About the only method
linarily employed is the separation of the plump and heavy seed
m the poor and light seed by means of screens and air blasts.
me systematic method of breeding simple enough to be satisfac-
y for general use should be generally adopted.

Unlike the corn plant, wheat is normally self-fertilized, almost no
ssing occurring naturally, and for this reason the individuals or
ts grown need not be isolated as in corn breeding. Doctor Webber

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A progress record of experimental inquiries, published without assumption of
onsibility by the Department for the correctness of the facts and conclusions
orted by the stations.

Compiled from California Sta. Bul. 181; Nebraska Sta. Bul. 104; New York Cor-
Sta. Bul. 251.

U. S. Dept. Agr., Farmers' Buls. 193, 210, 244, 267.

U. S. Dept. Agr., Farmers' Bul. 84, pp. 8–11.

considers it possible that without resorting to the generally com methods of hybridization and selection practical farmers may duce valuable varieties and also improve the yield of their own c The methods by which this may be accomplished are: (1) The s tion of chance variations or sports and the propagation from t of improved varieties; (2) the systematic selection of the l yielding plants from a well-known race to secure better-yiel strains; and (3) the selection of large heads for seed.

Attention is called to the fact that many of our best varietie races of wheat have resulted from the application of the first met or by the selection of individual plants of marked superiority. instance, the popular Fultz wheat had its origin in some beaut heads of smooth wheat observed in a field of Lancaster Red Abraham Fultz in 1862. The American races, Wheatland I Pride of Butte, and Gold Coin, and the well-known English ra Hopetown and Chevalier, are also accidental seedling variati The Pride of Butte, a wheat well known in California, was found i field of rye and saved for trial on account of its extreme vigor. G Coin, a seedling sport differing from the hybrid Mediterranean being bald and white, was found by I. W. Green, of New York, through five years' selection the type was fixed and the yield increa about 10 per cent.

While sports or mutations of wheat plants are very rare, t farmers watching for such superior plants and testing them are ev less numerous, and therefore most of these valuable hints of natu are lost. Every farmer should study different varieties of individu plants until he can recognize exceptional plants as to size of hea yield, quality and size of grain, number of stools, strength of stra and other desirable qualities. The search for promising plants shoul be begun as soon as the crop shows mature size of heads, and wh such plants are located they should be marked so that the seed m be secured when ripe. This work need not be limited to the selecti of actual sports or mutations, but should include generally supe plants, and by selecting as many of these as circumstances will p mit the probability of securing an individual of exceptional val greatly increased. The seed from each selected plant should be k separate and weighed, if the facilities are at hand, in order that co parisons may be made later on. Each one of these plants, which the first generation selections, should be given a number and bri described.

It is recommended that the seed of each plant be planted rately in a short row on a clean and well-tilled piece of gr These rows may be placed 1 foot apart and about every twe row should be planted with some standard variety for comp At the beginning of the ripening period the season of maturing ifferent rows must be observed to determine their relative earliness r lateness, and when fully ripe the rows should be compared with ach other and with the rows of standard varieties. Only those rows pparently ranking high in yield, free from or least affected by isease, such as rust or smut, showing no tendency to lodging or hattering, and those indicating the greatest hardiness should be elected for further propagation. After the superior rows have been hosen each row must be examined for uniformity of type and all plants not conforming to the general type pulled out and discarded. The grain or seed of each row is harvested and kept separately and given the number of the individual plant first selected. The record of yield, earliness, hardiness, etc., of each number must be carefully preserved.

The seed secured from these first generation selections is used for the propagation of the second generation according to the following plan:

Plant a drill row 17 feet long, using a definite rate of seeding; one-half ounce of seed per row would be at the rate of about 1⅓ bushels of seed per acre and should be thick enough. These 17-foot rows should be planted 1 foot apart, so that one row represents one-sixteenth of a square rod, or one two-thousand-five-hundred-and-sixtieth of an acre. Plant as many 17-foot rows from each kind as the amount of seed obtained will plant, but if more than one row is planted place them in different parts of the field. in order to obtain a better judgment of the variation due to soil. In planting the 17-foot rows at least every twentieth row should again be planted with a standard variety for comparison.

When the grain is ripe all inferior rows are again discarded, the best rows harvested separately, the grain from each row weighed for comparison with other rows as well as with the standard varieties, and the results recorded.

The third generation is grown in 17-foot rows from the seed of all of the second generation rows selected, and the results of this year should point out the best-yielding strains. It is advised that of a few of the very best and highest-yielding strains somewhat larger plats be grown this year to increase the seed for more extensive planting in the fourth generation. A few of the best-yielding strains should be saved from this year's crop for more extensive trials in the fifth year

For the fourth generation 17-foot test rows are planted with the strains retained from the third generation and these are compared with some standard variety. If possible, several test rows of the standard varieties should be grown in different parts of the test plat. At maturity the grain of each test row is harvested and weighed separately, as heretofore, and the yield records carefully made and preserved. By comparing the yields of the test rows and increase-plats of each strain for the three years with each other and with the yields of the standard varieties the highest-yielding [illegible] retained for extensive trial may readily be determined. All strains inferior to any other grown and to the standard varieties should be discarded. At this point of the work it is suggested that but two or three strains, or only one, if it is markedly superior, be retained for planting as large a field as possible the following season. If the results show that a superior variety of a high-yielding capacity has been secured the seed should be distributed as extensively as the quantity justifies, and if extensive tests prove it to be a superior variety it should be given a distinctive name.

The method just presented is based upon selecting entire plants and getting the total product of different plants in beginning the selection. In some cases large fine heads from apparently good plants are selected and the product of each head or ear planted in a row by itself, the same as is described for planting individual plants, except that since there will not be seed enough for the 17-foot row the rows are made shorter in accordance with the amount of seed in the heads selected. Ordinarily these will furnish enough for one or two 17-foot rows the next season and the further tests are carried out exactly as already described.

The selection of well-known races to secure high-yielding strains should be carried out in different years in exactly the same way as above outlined. A standard variety, well adapted to local conditions, may be improved by selecting and testing the highest yielding plants. The tests of these plants through the several years are carried out exactly as described for the selection of chance variations and sports.

The simplest application of the method of selecting large heads consists in examining the field of a good standard variety and gathering a quantity of the largest heads, at least enough to make a bushel or more of seed. The following year this seed is grown in an increase-plat and when the grain is ripe it is again gone over and enough large heads gathered for a similar-size plat the third year. The remainder of the crop of this increase-plat is used to plant the general crop of the third year. This method continued year after year will result in good seed for planting.

The methods just described for the improvement of wheat may also be applied to the improvement of oats and barley. The breeding of these crops is much neglected and varieties are frequently very much mixed with different types. It is pointed out that in oat and barley breeding attention should primarily be directed to securing the best-yielding strains for a certain region, and secondarily to producing early or late varieties and to the improvement of the quality of the product. In oats a heavy grain is important and white is the preferable color. In breeding oats and barley careful attention must be given to the susceptibility to disease, lodging, and shattering.

That the grade of seed wheat generally used is not up to the standard was ascertained in an investigation by G. W. Shaw, of the California Station, who secured a large number of samples of seed wheat over a wide area in the Sacramento and San Joaquin valleys of California, to determine the general character of the seed used by the farmers of the State. In general the samples showed that the quality of seed used by most farmers is lacking in purity, perfection of development, weight per bushel, freedom from weeds, and freedom from bunt. It is stated that practically all investigators have found the use of large plump seed and of a high weight per bushel the most profitable. No permanent benefit is believed to be secured from the frequent exchange of seed unless a better type of wheat or a more vigorous strain of the same type is obtained by the exchange. The use of seed from heavy-yielding plants, a plump and heavy grain, a clean wheat, and a pure variety are considered by him the most important points in seed selection.

In this connection the results secured by E. G. Montgomery, of the Nebraska Station, in an experiment with seed wheat and seed oats selected by the use of the fanning mill are of interest. In these experiments heavy seed wheat as separated by the fanning mill did not show an improvement in either yield or quality of grain as compared with light or unseparated seed, and it is believed that no permanent improvement in quality or yield is to be expected from the use of the fanning mill in seed selection.

> At first thought it would seem that if "like produces like," the large or heavy seeds should produce the best crop. However, we must recognize the individual plant as the unit for selection, rather than the individual seed. If a single plant of wheat be taken and the kernels thrashed out it will be found that all sizes of kernels are produced by the plant, some large and some small.

As every wheat plant contains both heavy and light seed, the fanning mill gives almost the same kind of wheat so far as inheritance is concerned in the light wheat as in the heavy. It must be remembered that reference is made here to the permanent results which may be expected from the use of the fanning mill and that its use or the use of screens for removing obnoxious weed seed is in no way discouraged, and where a large proportion of the seed grain is shrunken, immature, or damaged this method of seed selection will without doubt increase the following crop by the removal of the poor seed.

SORGHUM FOR SILAGE.[a]

Sorghum has not generally been considered as satisfactory as corn for silage. Professor Plumb, of Ohio State University, states that "sorghum is not so nutritious as Indian corn. The stalks are more dense and the silage is not relished quite as well by cattle as that from corn."

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[a] Compiled from Florida Sta. Bul. 92; Illinois Sta. Bul. 101; Kansas Sta. Bul. 123; Tennessee Sta. Bul., Vol. XVII, No. 1.

In experiments at the Tennessee Station, however, A. M. Soule found that "as fine a quality of silage can be made from sorghum as from any other crop and there seems to be little choice between the feeding values of sorghum and corn silage for beef production." He states that "farmers who experience difficulty in making good silage either cut the crops too green or else have improperly constructed silos."

In the Tennessee experiments the cost of growing an acre of sorghum silage was $19.48, of corn $14.92, corn and sorghum $19.14, soy beans $19.86, but the average cost of a ton of silage from sorghum was $1.41, from corn $2, from corn and sorghum $1.86, and from soy beans $2.83, the higher yield per acre of the sorghum accounting for the lower cost per ton.

Sorghum planted as a "second crop" will not yield more than 8 to 9 tons per acre, whereas if planted as a first crop it will yield from 12 to 20 tons per acre. The lowest cost per ton from a first crop was $1.15 and the highest $1.78; from a second crop the cost was about $2.80.

In the Tennessee experiments Red Head was found to be one of the best varieties for silage purposes. Grown with Virginia ensilage corn a very satisfactory combination for silage was obtained. "Combining these crops makes a better quality of silage, increases the yield, and reduces the cost per ton as compared with corn alone. * * * Corn and sorghum can be combined so that the resulting silage will consist of about equal percentages of each crop."

Sorghum, like corn, contains an excess of carbohydrates and is somewhat deficient in protein. It was found at the Tennessee Station that this could be corrected in a very satisfactory way, and a better balanced silage obtained by growing cowpeas and other leguminous crops with the sorghum and ensiling the two together.

In experiments at the Illinois Station it was found that while "in Illinois corn seems to be the best single crop for the silo * * * under average conditions a larger tonnage of feed can usually be obtained per acre by combining corn, sorghum, and cowpeas or soy beans, but even with this combination the greater part of the crop should be corn."

In comparative tests of different crops for silage at the Kansas Station "cane and Kafir corn gave the largest yields and lowest cost per ton of any of the annual crops, while corn ranked second, and cowpeas third."

The need for forage crops which will give large yields of good forage is becoming more pressing in the South as the raising of live stock increases. J. M. Scott, of the Florida Station, says that the value of *sorghum* for this purpose has not yet been fully realized. He finds that sorghum may be grown in all parts of Florida when cultivated and fertilized in practically the same way as corn. It seems to be the best and most productive silage crop that can be grown in Florida. Yields as high as 19 tons per acre were obtained. In the Florida experiments sorghum produced silage richer in total digestible nutrients and gave a larger yield of green forage per acre than corn, thus making it "not only the best crop for the silo, but also the cheapest."

DRY ROT OF CORN.[a]

According to T. J. Burrill and J. T. Barrett, of the Illinois Station, the group of diseases of corn known under the general name of dry rot has become of sufficient economic importance during the past four or five years to cause general concern among farmers in corn-growing regions.

> In 1906, the year in which there was the greatest amount of dry rot, so far as any records have been made, the loss was 4.5 per cent of the entire crop in Illinois. This represents a loss of over 15,000,000 bushels, having a value of more than $5,000,000. The loss in 1907 was less than 2 per cent of the crop, or about $2,000,000.

The name dry rot is derived from the way the ears are affected in the field. "In general the husks tend to turn prematurely yellow to sooty, and the ear becomes partially or wholly shriveled and much decreased in weight. Sometimes the ears remain upright with the husks closely adhering to them. In other cases the shanks are weakened and the affected ears hang limp from their attachment, or the diseased condition may not be detected until the husk is removed."

There are several kinds of dry rot, due to different causes. The most common and that which, according to Burrill and Barrett, has during the past two seasons caused about 90 per cent of the damage in Illinois, is due to a fungus known as *Diplodia maydis*. Ears infected with this fungus "shrivel up more or less, darken in color, and become light in weight."

> The kernels are also shriveled, very brittle, and loosely attached to the cob. The fungus penetrates all portions of the ear, kernels, cob, and husks, and produces many dark-brown, two-celled spores which serve to propagate the fungus.
>
> There are several other forms of dry rot which are less important but cause considerable damage which seems to be on the increase. These are also due to fungi which belong, for the most part, to the genus Fusarium—members of which cause serious damage to quite a number of our important cultivated plants. * * *
>
> In the case of the Diplodia disease, and quite probably in that of the other forms, the fungus perpetuates itself over winter on the old diseased ears and old stalks. It is not usually difficult to find throughout the summer in old corn fields, where the disease has previously prevailed, many pieces of old cornstalks which are infected with the Diplodia fungus. Stalks known to be two years old have been found still producing spores. During moist periods, spores ooze from these stalks in abundance and are

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[a] Compiled from Illinois Sta. Circ. 117.

blown singly or in masses long distances, as has been frequently demonstrated by experiment.

The fungus does not, according to present knowledge, grow upon any other host, and upon developing corn only on the ears. Not so much is known of the other fungi here concerned, but since 90 per cent of the rot is due to Diplodia, less attention need be given to them. Diseased ears are fruitful sources of subsequent infection and should be removed as promptly as possible. This can be readily done, at the time of husking if not before. Keep them in a separate receptacle and burn them as soon as practicable. In addition to this, in fields where any considerable amount of disease has been found, the stalks should also have attention, whatever crop is to follow. Something may be gained by carefully plowing them under and leaving them well covered, but burning may be required even if this is otherwise bad procedure. Such a field should not be replanted to corn for at least two years.

If the first suggestion is always followed and the others are put into practice whenever necessity demands it, these serious losses may be practically prevented.

MANUFACTURE OF STARCH FROM SWEET POTATOES.[a]

With a view to the more complete and profitable utilization of the sweet-potato crop the South Carolina Station several years ago began investigations to determine the starch content of different varieties of sweet potatoes and those most promising for starch making, how much starch can be recovered commercially from the potatoes, and the quality of the starch for commercial purposes.

As it is usually managed at the present time, only a fraction of the crop is disposed of, all unmarketable potatoes being usually a dead loss, and frequently, through inability to market the crop promptly, great loss is suffered through damage by rotting, etc. Where the crop could be disposed of to starch factories the grower would have the following advantages: (1) All potatoes could be sold, regardless of their size. (2) No barrels or containers would be required in marketing the crop. They could be loaded into a wagon in the field and hauled directly to the factory, or to the nearest railroad and loaded into cars for shipment. (3) Grown on such a large scale, modern machinery could be employed in planting, cultivating, and harvesting the crop, thus reducing the cost of growing. (4) Heavier yielding varieties could be grown, which are the ones most valuable for starch production.

The earlier experiments dealing with the economy of the sweet potato as a starch producer have been described in a previous bulletin of this series.[b] The later experiments, which it is the purpose of this article to describe, deal with the methods and economy of the manufacture of starch from sweet potatoes and the commercial value of the product.

Up to the time when the study of the question of producing starch from sweet potatoes was begun at this station, it was a subject that had received practically no attention in this country. It is true, starch was made from this plant on a small scale in the Southern States during the war, but the starch obtained in this way was a comparatively impure product and intended only for home consumption.

It would seem that the sweet potato could be profitably used for this purpose, as it contains a larger percentage of starch than the Irish potato, yields a heavier crop, and n be grown more cheaply. Another advantage it has over the Irish potato is the ct that the vines of the former make a good food for stock—some varieties being very latable, making good hay and excellent silage. In composition they compare vorably with other forage crops.

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[a] Compiled from South Carolina Sta. Bul. 136.

[b] U. S. Dept. Agr., Farmers' Bul. 87, p. 26.

The development of cotton manufacturing in the South has created a demand, hich is continually increasing, for starch used in "sizing" yarn and "filling" cloth. t present every pound of this starch is brought from other States, principally from the rnstarch factories of New York and Illinois. The experiments which we have had rried out show that for use on cotton goods the starch produced from sweet potatoes better than cornstarch, and fully equal to the best grades of Irish-potato starch. he annual production of sweet potatoes in the South Atlantic and Gulf States is about ,000,000 bushels, but this might be easily increased tenfold. The theoretical nount of starch produced per acre from a good crop of sweet potatoes is from one and e-half to four times as much as from corn, wheat, or Irish potatoes per acre.

The variety most in demand for a table potato is not necessarily the one best suited r the manufacture of starch. In fact, we can say almost conclusively that it is not, the variety containing the largest percentage of starch is apt to be dry and insipid. ıen, too, for starch production we want a prolific potato, and as a rule the heaviest elders are not of the best quality for the table. It has not been fully determined as t what varieties are best suited for the manufacture of starch. These are the most sential requirements: (1) High starch content; (2) prolificness; (3) flesh light, or ite in color. The following come nearer possessing these requirements than any have thus far examined: Providence, Southern Queen, and Triumph. Further rk may show that there are other varieties better suited for this work than any of ose mentioned.

The machinery used in the station experiments was similar to that ed in making starch from Irish potatoes.

Four varieties of potatoes were used—Southern Queen, Providence, iumph, and Red Nansemond. The first three were chosen for eir high starch content and light color, and one test was made of ed Nansemond to see if the color would interfere with successful arch making.

The results of experiments carried out for two years in succession ow the entire practicability of the manufacture of starch from eet potatoes, but "the data accumulated is yet insufficient to ake any positive statement as to whether engaging in this enterrise will prove a paying investment."

At the price at which sweet potatoes are sold at the present time their manufacture to starch alone would not be profitable. It must be remembered, however, that, own on the scale which would be necessary to run one or more starch factories, ere are a number of expenses which could be eliminated. * * *

In the conducting of a factory the following plan suggests itself as a feasible one: e factory to take over all potatoes from the farmer, select the best and even-size es to be shipped to market for table use, and make starch from the small, overe, and ill-shaped ones. All operations being controlled in this way by the facry on a large scale, the product could be utilized and marketed to the best advange. In case of dull market conditions, instead of shipping the potatoes they could canned, for which there is a great and increasing demand at the present time.

A successful method has also been devised for evaporating sweet potatoes. In is condition they will keep indefinitely, and, owing to their concentrated form,

> can be shipped long distances at comparatively small cost. They would, no doubt, be quite popular if better known.
>
> As is the case in all paying enterprises, it would be necessary to watch carefully the by-products and utilize them to the best advantage. A method could undoubtedly be devised for collecting the water with which the potatoes are treated in the grinding operation. This would contain the greater portion of the sugars and could be added to the pulp—from which starch has been extracted—and all sugars, starch, and fermentable matter remaining could be converted into alcohol. It has been shown that, theoretically, 50 gallons of 95 per cent alcohol could be produced from the residues from 100 bushels of potatoes.
>
> It is practically settled that the starch produced from sweet potatoes is of a high grade and suitable for use in many operations where a high-grade starch is required. In all of the tests we have had made not a single adverse report has been received.

In practical tests for laundry purposes, for sizing yarn, filling cloth, thickening colors, etc., the starch gave highly satisfactory results.

PROFITS FROM TOMATO GROWING.[a]

In a recent bulletin of the West Virginia Station, W. M. Munson says:

> Next to the potato, the tomato stands, perhaps, at the head of the list of garden vegetables in commercial importance. In Maryland, New Jersey, Delaware, Ohio, Indiana, and to a rapidly increasing extent in West Virginia, the crop is of special importance, while the greenhouses of New York and New England and the newly developed truck fields of Florida endeavor to supply the demand for this fruit in winter.
>
> By far the larger portion of the area devoted to this crop is employed in supplying fruit for the canning factories, and it is the demand of the canneries which more than any other has given the great impetus to tomato culture

It is shown that the canning industry has increased from a pack of about 3,000,000 cases of 24 cans each in 1887 to 13,000,000 cases in 1907. Professor Munson states that the average yield per acre in this country, as grown for the canneries, is 125 to 150 bushels, but that the man who makes a specialty of tomatoes will not be content with less than twice the amount named. "It is better to cultivate fewer acres and cultivate them well than to attempt to cover too much ground. Even at 200 bushels per acre, however, the returns will be far greater than can be derived from wheat, corn, or other farm products."

As regards profits from forcing tomatoes, Professor Munson states that his experience is limited to New York and New England, where, owing to the low temperatures and the excessive number of dark, cloudy days, the yields were not large.

> In Maine the yield per plant with the best forcing varieties was 2½ to 3 pounds. In New Jersey the average yield reported is somewhat larger. On the basis of 3 pounds per plant, however, the returns at 30 cents per pound, or 25 cents at wholesale, are very profitable, being about 50 cents per square foot of bench space for each

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[a] Compiled from West Virginia Sta. Buls. 116, 117.

p. Of course these figures can not always be relied upon, for unforeseen conditions quently arise; but, on the other hand, the experienced gardener will by the use other crops, as lettuce, radishes, and cucumbers, utilize the space in the house as to provide against these unforeseen factors.

The opinion is expressed that "as a simple business proposition, owever, tomato growing offers excellent opportunities at this time."

Professor Munson summarizes his twenty years' experience in the ulture of tomatoes in the field and in the greenhouse substantially s follows:

Field culture.—One of the most important problems in tomato culture is that of earliness. As a rule, plants purchased of the local dealers are drawn and "leggy," being crowded together in small boxes. When set in the field where too often the soil is hard and dry, the shock is such that several weeks are required for the plants to recover and no fruit sets until late in the season. In general, these weak drawn plants are not worth setting.

Frequent transplanting before setting in the field is the best method of securing strong, stocky, well-developed plants. The practice usually followed by the writer has been to sow the seeds in hotbeds, or in shallow boxes in the greenhouses, about April 1. When the first true leaves have well started, or as soon as the plants begin to crowd, transfer to 2-inch pots, and later to 3-inch and 4-inch if occasion demand. As a rule, however, in this climate it will be unnecessary to handle the plants more than twice. In the absence of pots the plants may be handled in boxes, or even in the bed; but pot-grown plants are always preferable, as they are checked less by removal to the field. In the field the plants are set about 4 by 5 feet. Many would plant closer, but on reasonably rich ground the plants will cover the whole surface if set at this distance.

The plants should be set in the field as soon as danger from frost is past. It has commonly been taught that any chill is nearly fatal to young tomato plants; but, as shown by the writer's work at Cornell University and at the Maine Experiment Station, "a chill is not as fatal to success as is commonly supposed." At the Maine Station it was found that "in every instance, save one, the first ripe fruits were obtained from plants set latest." This fact, however, is not necessarily an indication of earliness, as the late-set plants were older than is usually desirable for setting, and the first fruits were in some cases from blossoms formed while in the house. After these had ripened, there was a long interval before others followed. "Without exception the average number of fruits, and the average weight of the product per plant, was in direct ratio with the earliness of setting."

As stated in Bulletin 116 of the West Virginia Station—

The notion that tomatoes do better upon relatively poor soil is erroneous. While it is doubtful if an excessively heavy application of stable manure would be profitable, a liberal application, such as would be given for a good crop of corn, may nearly always be used with advantage. At the Cornell Experiment Station it was found that "the results obtained with liberal manuring, under commercial conditions, * * * certainly show that good stable manure in abundance could be used profitably."

Some of the best tomato soils are the newly cleared areas designed for orchard planting. But on these same new soils, an application of about 500 pounds of a good high-grade complete fertilizer will usually be found advantageous.

Trimming the vines in midsummer as a means of hastening maturity and increasing the yield of fruit is frequently recommended, but very seldom practiced, even by amateurs. In the writer's experience the results obtained justify greater emphasis of this point. As a result of two successive seasons' work at the Maine Experiment

Station it was found that the total increase in the number of fruits matured, due to trimming, ranged from 5.5 per cent to 50 per cent. The percentage gain by weight was very marked, and in one instance reached a total of 58 per cent. In these trials the plants were grown under ordinary field culture. They were started in the greenhouse April 1, planted in the field June 1, and headed back July 24, August 8, and September 5. At each trimming the leading branches were shortened about 6 inches, and most of the side shoots below the first clusters of fruit were removed, the others being shortened. The sunlight was thus freely admitted to the fruit and picking was rendered much easier.

Tomato growing in winter.—Successful tomato culture under glass depends as much upon the man in charge as upon conditions. Eternal vigilance and the exercise of good judgment on the part of the grower are more essential than strict adherence to set rules. The crop is one which demands constant care and intelligent management, but under suitable conditions the returns are very satisfactory, and the product meets a ready demand at good prices.

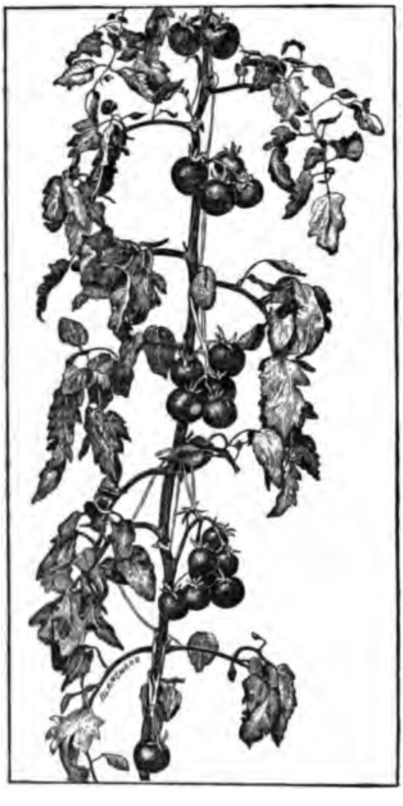

FIG. 1.—Single-stem plant in forcing house, showing method of tying fruit cluster.

The most important conditions for forcing tomatoes are: A warm, light house—one having a two-thirds span facing the south being preferable—strong bottom heat, rich soil, careful training, uniform temperature, care in watering and pollinating, and, as before suggested, good judgment and constant watchfulness on the part of the grower. Bottom heat is not absolutely essential to success, but the crop matures more quickly if given this condition.

To make the best use of the house two crops should be grown during the season. This will bring each crop on at a season when the expense of heating during a part of the time will be slight. Plants for the first crop should be started as early as the 1st of August. If two or more houses are available, a second sowing should be made in about three weeks, to give a succession. For the second crop seed should be sown during the latter part of October.

The plants are treated in every way as for outdoor culture till handled the last time. For fruiting some prefer benches, with about 6 inches of soil; but, in the writer's experience, the best results have been obtained from the use of boxes 18 inches square and 12 inches deep. In the bottom of the boxes is placed a layer of charcoal, broken pots, or "clinkers" from the furnace, after which soil, consisting of three parts good garden loam and one part well-rotted stable manure, is filled in to within 2 or 3 inches of the top. Each box will hold 4 plants, and the check caused by the partial confinement of the roots seems to be of value in hastening maturity. If the solid bed is used instead of the boxes, the plants are set about 16 inches apart each way, thus occupying a little more than 1½ square feet of floor space for each plant.

Best returns usually follow where the plants are trained to a single stem, as shown in figure 1. Flax cords, about the size of wool twine, are fastened to the corners of the boxes or to wires placed parallel to each row, for that purpose, and attached above to wires running lengthwise of the building, on the rafters or sashbars. The plants are secured loosely to this support by means of short pieces of raffia. All side shoots should be pinched out as soon as they appear; and when the plants are about 5 feet high, or when 4 clusters of fruit have set, the terminal buds should be pinched off. The vitality of the plant will then be expended in the development of fruit. If the plants are not headed back, other fruit clusters will form, but these scattering later clusters will unduly prolong the fruiting season without giving sufficient financial return to warrant delaying the removal of the old plants.

As the fruit sets the clusters should be supported by means of a small cord or piece of raffia passing around the main stem above a leaf, thus forming a sling. At this time, too, it is well to stir the surface of the soil and work in a quantity of well-rotted manure or to give frequent applications of liquid manure.

The temperature of the house should be as nearly uniform as possible—about 60° F. at night and 70° in dark weather, but 80° or even higher on bright sunny days. All cold drafts and sudden changes of temperature should be rigidly avoided.

Various phases of tomato culture have been discussed in previous Farmers' Bulletins.[a]

THE KEEPING OF APPLES.[b]

In a bulletin of the New Hampshire Station F. W. Morse brings out in a very striking manner the fact that the steady loss of weight which fruits such as apples undergo even under most favorable conditions in storage is due to a process of breathing similar to that occurring in animals, whereby oxygen is taken in and carbon dioxid given out.

Since apples and other fruits have no body heat to maintain, the breathing process is not so active as in animals, and they may last months after being picked from the tree. Yet there is a steady, continuous loss in weight as the weeks go by, although the fruit is sound and firm.

This breathing or respiration is stated to be "partly a chemical reaction, and in apples, like most chemical reactions in the laboratory, it grows more rapid as the fruit becomes warmer and is slowed down when the fruit is cooled." Professor Morse's experiments indicate that these chemical changes "take place from four to six times as fast at summer temperatures as in cold storage, and from two to three times as fast in cool cellars as in cold storage."

There is a practical application of this law to be made in the case of [illegible] at apple picking time.

It is frequently the case that warm days with temperatures of 70° F. [illegible] ber, and sometimes continue for a considerable period. Fancy apples intended for long keeping in cold storage should be picked as soon as grown and kept cool. The breathing process is at the expense of the contents and must weaken the keeping qualities as it goes on. And this [illegible] out of cold storage as inside it.

Another fact in connection with the respiration is important [illegible] cold storage, but simply slowed. Apples can not be kept indefinitely [illegible] twice as long in cold storage as in a cool cellar.

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[a] U. S. Dept. Agr. Farmers' Bul. [illegible]

[b] Compiled from New Hampshire Sta. Bul. [illegible]

VITALITY OF WEED SEEDS IN MANURE.[a]

It is well known that there is considerable risk of introducing new weeds by the purchase of manure and hay and other feeding stuffs (see below). E. I. Oswald, of the Maryland Station, undertook to obtain more definite information on this point, especially as regards dissemination through manure, by studying the effect of the fermentation of manure handled in different ways and of passing through the digestive systems of animals on the vitality of various weed seeds, including seeds of about fifty of the worst weeds found in Maryland.

In experiments in which the manure remained (1) for six months in a barnyard heap, and (2) for a short while in piles as when shipped in carload lots from cities, it was found that in the first case there was no danger and in the second case little danger of distributing live weed seeds. In the experiments in which the weed seeds were fed to yearling steers and the manure handled in various ways it was found that—

(1) Where the manure was hauled directly from the stable as a top dressing an average of only 12.8 per cent of the seeds fed to animals germinated.

(2) Where manure was hauled directly from the stable upon the land and plowed under 2.3 per cent of the seeds fed to animals came up.

(3) Where the droppings remained on the pasture fields unadulterated as they fell an average of only 3.1 per cent of the seeds fed to animals germinated.

The results indicate that in general it is safe to assume that the vitality of weed seeds is destroyed in well-rotted manure, but that many pass unharmed through the digestive tracts of animals and may be carried to the land if the manure is not well rotted before use.

WEED SEEDS IN FEEDING STUFFS.[b]

Several of the experiment stations having charge of feeding stuffs inspection have called attention to the danger of dissemination of noxious weeds through the use of feeding stuffs containing weed seeds. Attention has especially been called to this matter by the Maine and Vermont stations. That the danger from this source is quite serious is shown by the fact that it was found on examination at the Maine Station that live weed seeds were found in considerable numbers in many different kinds of feeding stuffs, including bran, middlings, brewers' and distillers' grains, malt sprouts, mixed feeds, chops, stock and dairy feeds, molasses feeds, flax feeds, etc. In some cases as high as 50 per cent of the feed consisted of weed seeds.

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[a] Compiled from Maryland Sta. Bul. 128.

[b] Compiled from Maine Sta. Bul. 156; Vermont Sta. Bul. 131.

"It is quite certain that many of these weed seeds would pass unharmed through the digestive organs of the animals to which they were fed and would find their way to the fields of the owner."

In a bulletin of the Vermont Station J. L. Hills and C. H. Jones, discussing this subject, say:

> It is a matter of common knowledge that there are sold yearly hundreds of carloads of wheat screenings (which being interpreted means in the main weed seeds screened from wheat prior to the milling process). Sheep and poultry handle them well, but the digestive system of neither horse nor cow is able to destroy them.

In the examinations made at the Vermont Station weed seeds were found to be especially abundant in certain samples of oat feed, mixed wheat feed, and molasses feeds. It is estimated that "the buyer of a ton of one brand of these molasses feeds purchased therein three weed seeds for every square foot of a hundred-acre farm, 129,000,000 weed seeds to a ton, bought and paid for by the farmer who wonders why he is pestered by so many weeds." The Maine Station also found that certain of the molasses feeds were flagrant offenders in the matter of carrying live weed seeds.

The Maine Station calls attention to a particularly objectionable kind of weed seed which is especially likely to occur in injurious amounts in wheat feeds and by-products, viz, cockle. A feed which contains as much of this seed as was found in some of the samples examined by the Maine Station "is objectionable not only on account of the crop of plants which might be grown, but because of its possible injury to stock."

It is thus made clear that the tendency to introduce foul seeds into the seeds and by-products used as feeding stuffs is a serious one.

For the most part there is little known as to the nutritive qualities of these weed seeds; occasionally, notably the case with corn cockle, they are poisonous. They are a great menace to clean fields. Naturally the use of these feeds high in foreign weed seeds will tend to the introduction of undue numbers of undesirable plants and sometimes of plants unknown to the State. In some of the feeding stuffs in the method of preparation they are heated to a high enough temperature to kill the seeds.

The national food and drug law forbids the presence of poisonous weed seeds in poultry and cattle foods. Director Woods of the Maine Station is of the opinion that in addition to enforcing this prohibition of the national law regarding poisonous seeds, it would be desirable and probably practicable for the States to also place a limit to the amount of weed seeds of any kind that should be allowed in feeding stuffs. He says:

> It would seem unwise to attempt to regulate the amount of weed seeds that are present in grass seeds and allow an unrestricted sale of feeding stuffs carrying in some cases more dangerous seeds than grass seeds carry.

FORAGE CROPS FOR PIGS.[a]

The question of forage crops for pigs is one which is of decided importance, as it is well known that the use of such feed is valuable and profitable. The question has been studied at a number of the agricultural experiment stations and has been referred to in earlier bulletins of this series.[b] Of more recent work that of the Mississippi Missouri, and Colorado stations may be mentioned.

Cowpeas without grain have so far given better results at the Mississippi Station, it is stated, than any other of the crops tested. In one season the cowpeas were grown on thin hill land and produced 350 pounds of pork per acre when pigs were grazed upon them. The next season the crop was grown on good valley land and produced 483 pounds of pork per acre. The pigs were turned on the pasturage when the cowpeas were ripe. Alfalfa without grain was found "to be little more than a maintenance ration for hogs." The pigs used in the test, which covered two years, ranged from 3 to 24 months in age.

Alfalfa, clover, rape, and blue grass supplementing corn were compared with rations of corn and ship stuff and corn and skim milk at the Missouri Station. The corn meal, which was of medium fineness, was mixed with water to the consistency of a thick dough and was fed twice daily in such quantities as would be eaten without waste. In the skim-milk ration the meal was wet with milk instead of with water. The green crops were fed twice daily immediately after cutting and were supplied ad libitum. The rape was rather large and coarse and only the fresh green leaves were used. Some of the alfalfa was rather too mature and coarse to be eaten with relish but the remainder was considered of fairly satisfactory quality. The red clover and blue grass were for the most part young and tender.

> It was not expected that in ordinary farm practice the green material would be cut and fed to the hogs in this manner. At the time the experiment was undertaken, however, it was not feasible to fence off areas of each of these forage crops and graze them; besides, to know what amount of each of these green forage crops was consumed by hogs when full fed on corn was deemed to be information of importance both from a practical and a scientific standpoint. Outside of the extra expense required for cutting and hauling this material to the hogs, it was not considered that they would do so well on this material as if allowed to graze, for when grazing they would be able to select their material and would eat a larger quantity of forage than it was possible to get them to consume in a pen when it was cut and fed to them in the manner described.

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[a] Compiled from Colorado Sta. Bul. 123; Mississippi Sta. Rpt. 1905, p. 14; Missouri Sta. Bul. 79.

[b] U. S. Dept. Agr., Farmers' Buls. 84, 124. See also Farmers' Bul. 205.

he feeding was continued for one hundred and two days, except h the rape-fed lot which was fed for forty days only, the supply ape being then exhausted. Considering the first forty days, the s on green feed ranged from 0.58 pound per pig per day on the ration to 0.74 pound on corn meal and alfalfa, the gain on corn l and middlings being 0.61 pound and on corn meal and skim 1.53 pounds. Considering the whole test the average daily per pig on the rations containing green feed was as follows: meal and blue grass 0.63 pound, corn meal and clover 0.77 nd, corn meal and alfalfa 0.83 pound, corn meal and midgs 0.68 pound, and on corn meal and skim milk 1.61 pounds. smallest amount of grain per pound of gain, 2.83 pounds, was ed with the corn and skim milk ration, and the largest amount, pounds, with the corn meal and blue grass. The gain was t cheaply made on corn meal and skim milk, costing 2.83 cents pound, and was most expensive on corn meal and middlings, ting 4.07 cents. On the green feeds it ranged from 3 cents on n meal and alfalfa to 3.96 cents on corn meal and blue grass.

ccording to Director Waters—

> rhaps the largest single waste occurring on the Missouri farm at the present time at which comes from the too exclusive use of corn in growing and fattening hogs. cheapest and most easily applied remedy is a more general use of the proper forage s in summer and the use of some home-grown protein in winter. It is not of course denied that the hog is primarily a grain-consuming animal, but at the same time e plays an important rôle in economical hog production and deserves far more tion than it has yet received. * * *
>
> is not safe or even desirable to rely upon a single crop, excepting alfalfa where it is ured success, to furnish pasture for our hogs throughout the entire season. It is er to arrange for a succession of pastures from the beginning of the season until the are ready for market, making the feed richer and more concentrated toward the of the season and as we approach the finishing or fattening period. For this ose the following crops are recommended: Red clover or alfalfa, cowpeas, soy s.
>
> o provide a crop of cowpeas in the best condition for the hogs, it will be necessary elect some very early maturing sort and sow rather earlier than is advised for a eral crop. * * * For the best results the hogs should not be turned on the peas l the first pods are turning yellow. They will, however, make good pasture before s time, and if the hogs are needing pasture it is not advised to wait until that stage maturity.

In the opinion of Professor Cottrell, of the Colorado Station, mers living in the Plains region of Colorado will find raising and ttening pigs advantageous, and barley, wheat, milo maize, and afir corn are regarded as the surest grain crops for the dry-land farmg conditions which there prevail. The importance of supplementg grain is insisted upon.

According to Professor Cottrell—

> Grain is high priced in most sections of Colorado, and while a hog should ha grain every day of his life, at least half the weight of a 200-pound hog should from roughage—pasture or fodder. The best pasture is alfalfa. * * *
>
> Dwarf Essex rape stands drought fairly well if seeded as soon as the frost the ground. Winter wheat and rye make good early pasture, and sorghum seeded in the spring in fields of rye or wheat and will furnish pasture after has dried up.
>
> Good alfalfa hay is the best winter roughage to feed hogs. It can be fed and will increase the gains and improve the flavor of the pork. In a test ma writer hogs fed all the grain they would eat gained 400 pounds, while those f hay and grain gained 600 pounds.
>
> Where alfalfa hay is not available good, juicy, sorghum fodder improves th ness of hogs and increases the gains. * * *
>
> Hubbard squash is an excellent feed for fattening hogs and some Colorad use it as an exclusive feed for this purpose, but better gains and finer qualit will be secured when some grain is given with it.

In the station work which has been cited opinions differ son as to the most profitable forage crop, as would be expected, sin conditions vary in different regions. All the investigators agree, however, that grain should be supplemented by forag in order to secure the best results.

MARKET CLASSES AND GRADES OF HORSES AND MULE

Believing that "market classes of horses are not well unde and * * * that a clear setting forth of true market sta will do much toward establishing correct ideals on the part horse breeder and producer," R. C. Obrecht, of the Illinois St has made an investigation of Chicago and St. Louis horse ma which are considered similar to other markets of note, with a to clearly defining market classes and grades of horses and The first fact of importance brought out by this investigat "that the majority of horses which find their way to [the markets do not approach the degree of perfection demanded b intending purchaser."

> A correct understanding of the market classes will enable the farmer to form a estimate of the value of the horses which he has to sell; for without this the fa at a decided disadvantage in selling his horses, not knowing their real market In this way he may fail to get what his horses are worth or he may lose a sale by too much. Again, it often happens that he fails to distinguish clearly betw good and his poor marketable animals. As a result the dealer takes the de ones at a good profit and leaves the undesirable; thus the inferior horses are left country to become the parent stock.
>
> Few breeders can follow their consignments to market and so become famili actual market demands. As most of the horses that reach the markets are h

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[a] Compiled from Illinois Sta. Bul. 122.

lealers who make a business of buying in the country and shipping, the breeder never know how well he has succeeded in producing a marketable horse that command a high price.

'o form an intelligent estimate of the value of horses or mules, refore, it is necessary to have a thorough understanding of the :ket requirements and a correct understanding of the market sses and grades.

ıe principal factors that determine the market value of horses or mules are: Sound- , conformation, quality, condition, action, age, color, education, and general ›arance.

orses or mules of a general type are grouped into classes, for convenience and a ıite understanding; and in most instances the names of the classes are suggestive ıe use to which they are put. The classes of horses are divided into subclasses :h embody those of a similar type but slightly different in size, weight, action, or use to which they are put. Mules are not divided into subclasses.

ıe market classes are: Draft horses, chunks, wagon horses, carriage horses, road es, saddle horses, mining mules, cotton mules, sugar mules, farm mules, and draft es.

orses.—Draft horses are broad, massive, rugged, and compactly built, with great ;ht and strength. They stand from 15-3 to 17-2 hands high and in good flesh ;h from 1,600 to 2,200 pounds or more. The class is subdivided into light draft, ŗy draft, and loggers.

ıunks are short-legged, broad, heavy-set horses, the name of the class being indica- of their conformation. The subclasses are eastern or export, farm, and southern. class varies in weight from 800 pounds, the lightest of the southern, to 1,550 ıds, the heaviest of the eastern. They stand from 15 to 15-3 hands high.

'agon horses are those used principally where business requires quick delivery. y must have good action, a clean set of limbs, good feet and bone with an abundance ıality, be closely coupled, compactly built and have a deep broad chest indicative ınstitution and stamina. In this class are express, delivery wagon, artillery, and ıorses. They stand from 15 to 17-2 hands high and weigh from 1,050 for the light hts of artillery horses to 1,700 pounds for heavy fire horses.

ırriage horses, sometimes spoken of as "heavy harness horses," are full made, d bodied and smoothly turned with an unusual amount of quality, and must ›ss to a marked degree high action, with a fair amount of speed. They should › a long, well-arched neck, small neat head, a short, well-muscled back, long, level p, and well-developed thighs and quarters. The class is comprised of coach, cob, , and cab horses. They range in height from 14-1 to 16-1 hands and weigh from .o 1,250 pounds.

›ad horses are more lithe in build and angular in form than those of the carriage . They are sometimes spoken of as drivers or "light harness horses" and are lly driven to light-weight vehicles. A considerable speed is desired of some of individuals of this class, which is composed of runabout and roadsters. They e in height from 14-3 to 16 hands and weigh from 900 to 1,150 pounds.

ddle horses.—In this class are grouped those horses that perform their work under saddle, the requirements for which are sureness of foot, ease of carriage to the ', good manners, and ease of control. In order to be sure of foot they must have blique shoulder, high thin withers and a properly set pastern with an abundance ıergy. The above qualities together with a short strong back will give strength arrying weight and also an easy gait. The minimum height is 14 hands for a polo pony and the maximum 16-1 hands for hunters. The weight varies from 850 to 1,250 pounds. Grouped in this class are five-gaited saddlers, three-gaited saddlers, hunters, cavalry horses, and polo ponies.

Mules.—Mining mules are those purchased with which to operate mines. They are heavy boned, rugged, compactly built individuals, with large feet and strong constitution. They range in height from 12 to 16 hands and weigh from 600 to 1,350 pounds.

Cotton mules are lighter boned than miners and not so compactly built. They are round bodied, smoothly turned, and possess considerable quality. They range in height from 13-2 to 15-2 hands and weigh from 750 to 1,100 pounds.

Sugar mules are those shipped south to use on the sugar farms of Georgia, Louisiana, and other Southern States. They are taller, larger, and more breedy looking than cotton mules and have heavier bone. They stand from 16 to 17 hands and weigh from 1,150 to 1,300 pounds.

Farm mules are those purchased to be used on the farms of the Central States. They are somewhat lacking in uniformity of type and many of them are young and somewhat thin in flesh. An average height is from 15-2 to 16 hands and weigh from 900 to 1,250 pounds.

Draft mules are large heavy boned, heavy set mules that possess quality and ruggedness. They are used in cities for heavy teaming and by contractors for all kinds of heavy work, such as railroad grading, etc. They range in height from 16 to 17-2 hands and weigh from 1,200 to 1,600 pounds and upward.

The grades distinguish the good from the poor animals within the classes and subclasses. The grades are choice, good, medium, common, and inferior.

An animal to grade as "choice" must be sound and approach the ideal type, possess quality and finish, have good style and action, and be in good condition. A "good" animal should possess the essential qualities of his class but need not have the quality, condition, and finish necessary to grade as choice. A horse or mule of "medium" grade is likely to be plain in his make-up with a tendency toward coarseness, and somewhat of a lack of symmetry and condition. A lack of style, action, or soundness may also cause him to grade as medium. The lowest grade found in many of the classes is "common." Such individuals are wanting in most of the essential qualities that go to make them desirable. An "inferior" animal is of the lowest possible grade.

Owing to the fact that the point where two classes or grades meet and merge into each other is not always distinct, it is sometimes difficult to say just where certain animals that are not clearly typical should be classified. Again, if the demand exceeds the supply it is sometimes necessary to temporarily draw from a similar class of animals, or the price may advance and in this way equalize the demand. If, on account of a meager demand or an excess supply the price should drop, it is sometimes necessary to place some animals of one class in another, i. e., they will be purchased by a different class of trade.

The breed to which a horse belongs has but little influence upon his market value and the classes are not determined by the breeds, but by the individuality and conformation of the horse; however, a judicious use of choice pure-bred sires is best suited for the production of marketable horses.

Summarized statement of market classes with limits in height and weight.

Classes.	Subclasses.	Height, hands.	Weight, pounds.
Draft horses	Light draft	15-3 to 16-2	1,600 to 1,750
	Heavy draft	16 to 17-2	1,750 to 2,200
	Loggers	16-1 to 17-2	1,700 to 2,200
Chunks	Eastern and export chunks	15 to 16	1,300 to 1,550
	Farm chunks	15 to 15-3	1,200 to 1,400
	Southern chunks	15 to 15-3	800 to 1,250
Wagon horses	Expressers	15-3 to 16-2	1,350 to 1,500
	Delivery wagon	15 to 16	1,100 to 1,400
	Artillery horses	15-1 to 16	1,050 to 1,200
	Fire horses	15 to 17-2	1,200 to 1,700
Carriage horses	Coach	15-1 to 16-1	1,100 to 1,250
	Cobs	14-1 to 15-1	900 to 1,150
	Park horses	15 to 15-3	1,000 to 1,150
	Cab	15-2 to 16-1	1,050 to 1,200
Road horses	Runabout	14-3 to 15-2	900 to 1,050
	Roadster	15 to 16	900 to 1,150
Saddle horses	Five-gaited saddler	15 to 16	900 to 1,200
	Three-gaited saddler:		
	Light Heavy	14-3 to 16	900 to 1,200
	Hunters:		
	Light Middle Heavy	15-2 to 16-1	1,000 to 1,250
	Cavalry horses	15 to 15-3	950 to 1,100
	Polo ponies	14 to 14-2	850 to 1,000
Mining mules		12 to 16	600 to 1,350
Cotton mules		13-2 to 15-2	750 to 1,100
Sugar mules		16 to 17	1,150 to 1,300
Farm mules		15-2 to 16	900 to 1,250
Draft mules		16 to 17-2	1,200 to 1,600

PROFITABLE AND UNPROFITABLE COWS.[a]

This subject has frequently been discussed in the bulletins of this series[b] and the methods of determining profitableness or unprofitableness of individual cows have been quite fully explained. The following "true story" from records made by the Massachusetts Station enforces so strongly and concisely the lesson of the importance of studying the performance of individual cows in a herd with a view to weeding out those that are not only not profitable but are being carried at an actual loss that it is reproduced as it appears in a recent bulletin of the station:

THE PROFITABLE COW.

A year's record.—6,975 pounds milk testing 4.87 per cent fat equal to 340 pounds fat, equal to 396 pounds butter. Food cost of 1 quart milk 2.76 cents; 1 pound butter 22.9 cents. Profit from milk at 3¾ cents a quart, $31.38; from butter at 30 cents a pound, $31.31.

THE UNPROFITABLE COW.

A year's record.—3,141 pounds milk testing 4.38 per cent fat equal to 137.4 pounds fat, equal to 165 pounds butter. Food cost of 1 quart milk, 4.53 cents; 1 pound butter, 39.2 cents. Loss from milk at 3¾ cents per quart, $11.27; loss on butter at 30 cents per pound, $15.22.

Query.—Which kind of cows are you keeping? If you don't know, isn't it about time you found out?

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[a] Compiled from Massachusetts Sta. Bul. 120; Circ. 12.

[b] U. S. Dept. Agr., Farmers' Buls. 56, p. 3; 114, p. 21; 162, p. 24; 190, p. 14; 273, p. 21.

HOW TO ASCERTAIN THE PROFITABLE AND UNPROFITABLE COWS IN A HERD.

The same station suggests the following plan by which the farmer can, with "a minimum outlay of time and money, ascertain the profitable and unprofitable cows in his herd:"

WEIGHING THE MILK.

Begin when the cow is fresh and weigh her milk for three consecutive days in each month, preferably about the middle, and record the weight on previously prepared ruled paper. The sum of the amount produced for three days multiplied by 10 gives the amount produced for the month. The amount of milk produced in a portion of a month can be estimated by weighing the milk for one or two days and multiplying by the proper number. Continue the weighing for one year, and from year to year if you would know the whole truth. Preserve yearly summary in permanent record book.

The balance.—Any spring balance or scale will do, but [a] balance with the scale graduated into pounds and tenths, and with a movable pointer so that when the empty pail is suspended the pointer may be made to indicate zero, is to be preferred. [Such] scales cost $3 at any dairy supply house.

SAMPLING THE MILK.

When to sample.—Sample the milk of each cow in the second, fourth, and seventh month after calving; any time during the month will do, but the middle is to be preferred. The average of the three tests will be a fair index of the quality of the milk during the milking period. Thus if the milk tests 3.8, 4.2, and 4.8 per cent fat, the average would be 4.27 per cent for the entire period.

Utensils needed in sampling.—A pint jar for each cow, a small coffee cup or long-handled gill dipper for taking the sample, a box of bichromate of potash or corrosive sublimate tablets for preserving the sample,[a] to be procured of any dairy supply house at a cost of $1 to $1.25 per box.

How to sample.—Powder fine with a knife one-half of a tablet and put in each jar. Milk the cow dry and pour the milk as carefully as possible from one pail to another three times in order to mix it. Do not allow any more frothing (air bubbles) than possible. Dip out a cupful of the milk at once and pour into the jar. Mix the milk with the preservative by a careful rotary motion. Do not shake or turn the jar upside down. Proceed in this manner for four consecutive milkings (two full days). Be sure to mix the milk by the rotary motion each time a sample is added to the jar and keep the jar tightly covered. The jar should be marked with the name and number of the cow.

TESTING THE MILK.

The samples may be tested by the owner of the cow if he has a Babcock machine, glassware, and acid, or it may be taken to the creamery, or in exceptional cases sent to the experiment station.

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[a] A solution of formalin may be used in place of the tablets. It can be procured of any druggist. Add 5 drops with a medicine dropper.

Illustration of year's milk product.

Month.	3 days' yield.	30 days' yield.	Month.	3 days' yield.	30 days' yield.
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*
January	90 ×10	900	July	48 ×10	480
February	78 ×10	780	August	42 ×10	420
March	72 ×10	720	September	30 ×10	300
April	66 ×10	660	October	20 ×10	200
May	60 ×10	600	November	15 ×10	150
June	54 ×10	540	December	(Dry)	
Total		4,200	Total		1,550

Total 5,750 pounds milk×4.27 (average per cent fat)=245.5 pounds butter fat.

Converting butter fat into butter.—Increase the pounds of butter fat by ⅙ thus: ⅙ of 245.5 pounds butter fat=40.9+245.5=286.4 pounds butter produced during the year.

The above method as described is of course not strictly accurate, but sufficiently so to enable the farmer to form a fair estimate of the productive capacity of his cows.

WHAT IS A PROFITABLE COW?

(*a*) **For market milk.**—In order to be considered profitable, a cow should produce 6,000 pounds (2,800 quarts) of 3.5–4 per cent milk yearly, without being forced.

(*b*) **For butter.**—A cow ought to produce 300 pounds of butter yearly—if she does not do it, she is not helping you.

BLACKHEAD IN TURKEYS.[a]

Under favorable conditions turkey raising has proven to be a very profitable industry. Young turkeys are, however, very delicate and require a great deal of care, and destructive diseases sometimes appear to such an extent as to discourage the raising of turkeys. Among the most destructive of turkey diseases, attacking old and young, is the so-called blackhead. This disease has for several years past menaced the formerly profitable and highly developed turkey industry of Rhode Island, and has proved very destructive in other parts of the country. In fact, it is stated that the disease "has practically destroyed the turkey industry of New England and is rapidly depleting western flocks."

C. Curtice, of the Rhode Island Station, in cooperation with the U. S. Department of Agriculture, has made a very careful study of the nature of the disease, its means of transmission, and possible means of prevention or control. E. F. Pernot, of the Oregon Station, finding the disease very destructive in that State, has also made a study of it with a view to finding means of prevention or treatment.

The name blackhead is derived from the fact that the heads of diseased turkeys frequently turn black, although Doctor Curtice states it as his experience "that few young poults have black heads when they die, and that many old turkeys do not." The black appearance of the head, therefore, though common, has no necessary relation to the blackhead disease. Turkeys dying of other diseases may also have the head turn black.

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[a] Compiled from Rhode Island Sta. Buls. 123, 124; Oregon Sta. Bul. 95.

The seat of the disease has been shown to be in the liver and in the cecum or blind intestine. "In the former it is recognizable by discolorations often more or less circular or even quite irregular in form, and often presenting a yellowish appearance." In the cecum the disease is accompanied by great enlargement and the formation of large sores in the cecal wall.

> When the disease in the cecum is slight it is doubtful if the affected animals have diarrhea, which is more or less present in other cases. In many of the older poults the droppings will be liquid, and stained orange yellow; this is the most characteristic symptom of all. Sometimes there are blackened blood clots in the droppings, indicating slight hemorrhages. * * * The majority of young poults die after a day or two of droopiness. Adults may droop longer and pass into chronic stages of the disease. Refusal to eat and standing apart constitute late symptoms.

The experiments made by the Rhode Island Station indicate that the disease is not transmitted through the egg and afford strong evidence that while ordinary fowls (hens, guineas, pheasants, etc.) rarely die of the disease, they carry and distribute the disease.

> The experiments have shown that by removing the turkey eggs three or four days before hatching, wiping them with a cloth moistened with 90 per cent alcohol, finishing the incubation in a machine, keeping the poults for a few weeks on a disinfected board floor, and placing them in a location remote from ordinary fowl, the losses by blackhead disease prior to reaching maturity may be reduced from a minimum of 80 per cent to from about 15 to 20 per cent.
>
> This shows that the turkeys must be kept away from ordinary fowl as much as possible, and in view of the tendency of partially wild turkeys to roam and remain at a considerable distance from the farm buildings, it is possible that the supposed benefit from introducing wild blood is thus partially explained, and that it is not wholly due to greater immunity of the wild birds.
>
> It is popularly believed that turkeys can not be raised successfully in confinement; one reason may be that they are often confined with ordinary fowl, which give them the disease organisms.
>
> More must be known about the means by which this disease is transmitted before great progress in its practical control can be expected.

As the parasites seem to be easily killed by drying, dry sandy soils would seem to be preferable for turkey rearing, and it is clear that turkeys should be reared away from the house and be kept from all fields where ordinary fowl are likely to forage.

Older turkeys apparently resist the disease better than very young, but "no breed of turkeys thus far tested is immune to the blackhead disease, for all of them, at all ages, so far as tried, have died of it."

The destructive character of this disease and the ease with which it may be distributed suggests that great care should be exercised not to carry turkeys from regions where the disease prevails into regions where it does not exist.

EXTRACTION OF BEESWAX.[a]

In view of the increasing interest in apiculture in Colorado and the lack of definite information on the subject of the extraction of beeswax, an important product of the industry, F. C. Alford, of the Colorado Station, has made a study of the relative efficiency of different methods of extraction now in use. He experimented with solar extractors, those using steam, and those using pressure under water heated sufficiently to melt the wax. In the latter method he used water alone and water containing sulphuric acid.

The solar extractor used by Mr. Alford was simple in construction and can be made by anyone who is handy with tools. It consists of a wooden box about 30 inches long, 16 inches broad, and 6 inches deep. This box is lined with tin and near one end has a wire-cloth screen to allow the melted wax to run down into a pan at the lower end of the box. The waste wax and brood comb were placed in the upper part of the box, which was set at an angle toward the sun and covered with glass, preferably double. The size of the solar extractor will be determined by the amount of wax to be extracted. If desired, a lamp may be used to furnish additional heat. A hole should be cut in the bottom of the box, so that the heat of the lamp will strike the tin lining under the wire screen. The lamp should be protected from the wind. The use of a lamp increased the efficiency of the extractor about 1 per cent. A like increase was obtained by soaking the comb in water for several days before extraction—a practice followed by some bee keepers. Soaking the comb for three days in a 5 per cent solution of sulphuric acid increased the yield of wax about 5 per cent.

Three kinds of steam extractors were tested in these experiments. Tests were also made of pressure under water with and without addition of 5 per cent of sulphuric acid.

Pressing under water.—The comb, with some water, was put in a tub on the stove and the wax allowed to melt, but not to boil. A can was placed under a press and a slatted follower placed in the bottom of the can. Above this was placed a burlap bag and the hot water, melted wax, and comb were poured into the bag, the top of the bag folded over, a slatted follower placed on top and pressure applied by means of a screw. After some of the wax had been forced out, the water and wax were drawn off, the pressure relieved, the "slumgum" stirred, hot water added, and pressure applied again. The can, which fits under the press, has two holes which are stopped by corks. One is at the bottom and the other near the top. By pulling the cork out of the upper hole the wax which has risen to the top can be drawn off and by using the lower hole all of the wax and water can be removed. The whole apparatus must be kept as warm as possible. * * *

Sulphuric acid and pressure under water.—It was thought that the addition of acid to the water in the experiment might increase the efficiency of the method. The comb was heated in a porcelain-lined tub with a solution of 5 per cent commercial sulphuric acid. When the wax had melted it was poured into the sack in the press and pressure

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[a] Compiled from Colorado Sta. Bul. 129.

> applied quickly in order not to have the acid in contact with the metal any longer than necessary. The wax and water were drawn off, boiling water added, the slumgum stirred, and pressure applied again. This water was drawn off and put with the rest. As this was an experiment to determine the efficiency of the press a tin can was used, but in practical work it would be necessary to have everything acid proof, as hot acid, even when diluted, is very destructive to most substances. The can could be made of wood or porcelain-lined ware. The latter would probably be the better.
>
> This method was easy to manipulate and rapid and was the most efficient of all the methods used.

The results reported show that "the slumgum from 100 pounds of wax treated by the ordinary solar wax extractor will retain from 34 to 36 pounds of wax, which can be removed by heating with dilute sulphuric acid and pressing under hot water. [With] the best of the steam wax extractors used there remains in the slumgum about 7 pounds of wax which is obtainable by the use of the sulphuric acid and pressure. With the price of wax at 25 cents a pound it would pay to buy old slumgum and remove the wax by this method."

The wax obtained with the steam extractors "did not have a good color, and would have had to be refined before it could be used. The wax from the solar extractors was always a better color than that from the steam extractors. The wax formed by pressure under water was nearly as good in color as the wax from the solar extractors. The wax obtained by pressure under water containing 5 per cent of sulphuric acid was very good in color, in fact, almost as good * * * as most of the wax obtained from the solar extractors."

Wax from old brood comb is too dark to be used for comb foundation, so that some satisfactory method of bleaching must be employed. Various methods of bleaching were therefore tried, but most of them either destroyed the wax or were in themselves poisonous.

As a result of these experiments and from his experience in handling bees and rendering wax Mr. Alford expresses the following opinion:

> It is best for the average bee keeper to have a large solar wax extractor, heated by some artificial heat, by means of which most of the wax in the lighter colored combs, cappings, and burr combs may be easily rendered. The dark combs may also be treated in this manner and the slumgum stored in barrels until the bee keeper has time to treat it with dilute sulphuric acid and press under water. This method is quick and efficient. If the wax has to be refined it can be done by heating, while inclosed in a canton flannel sack, with a solution containing 5 per cent of hydrogen peroxid and 2 to 5 per cent of sulphuric acid. Both of these chemicals can be bought at the ordinary drug store. The common kind, commercial, should be used.
>
> In mixing the acid and the water care should be taken to always pour the acid gently into the water and not the water into the acid.
>
> The cost of the chemicals compared with the results obtained is very slight.

AN IMPROVED HOG COT.[a]

In a previous article[b] an A-shaped or wigwam hog cot used at the Wisconsin Station was described. Since that article was written the cot has been "considerably modified and improved in order to adapt it to both summer and winter conditions." Figure 2 shows the improved cot. A comparison of this figure with the illustrations in the previous article will show that the main additional features are a permanent floor, a door in each end, and a ventilating system, all of which greatly increase the stability and utility of the structure.

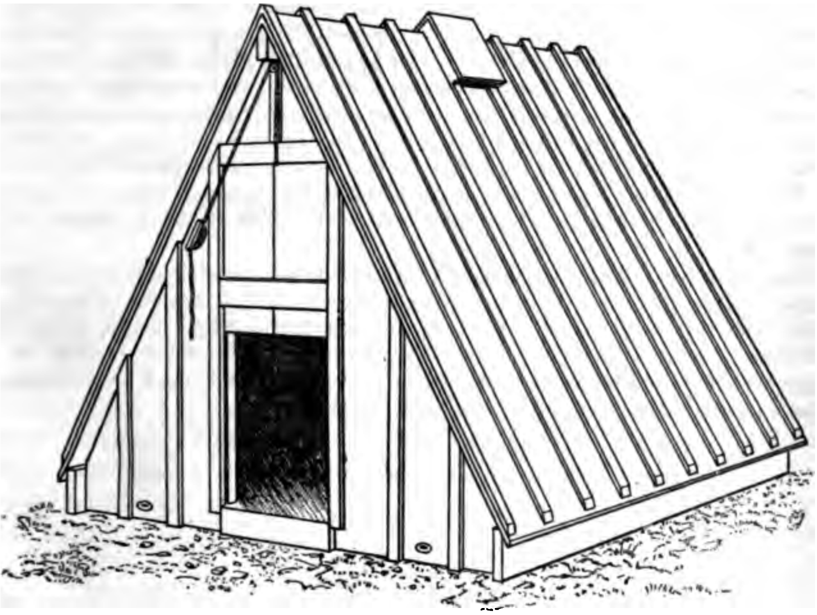

FIG. 2.—Front view of the A-shaped hog cot.

It is constructed by nailing inch boards on 6 joists 2 by 4 inches by 8 feet long for the floor. Beneath the joists are nailed 3 stringers 2 by 6 inches, 8 feet long, which serve as runners for moving the house. Next is spiked a piece 2 by 8 inches, 9 feet 4 inches long, at the ends of the joists, having the bottom of the 2 by 8 even with the bottom of the joist which will allow it to project above the floor 3 inches. It will also extend out 7 inches at each end. This 2 by 8 forms a plate to which the rafters and roof boards are nailed. The 7-inch extension of the plate at the ends supports the lower corners of the roof which otherwise would be easily split off. These 2 by 8's, besides strengthening the house, raise the rafters and roof boards nailed to them at least 3 inches off the floor and thereby materially increase the floor space and the capacity of the house.

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[a] Compiled from Wisconsin Sta. Rpt. 1907, p. 41.

[b] U. S. Dept. Agr., Farmers' Bul. 296, p. 27.

If the house is to be used in extremely cold weather an easily manipulated door is necessary. The cut shows a door 2 feet wide and 2 feet 6 inches high, made to slide up and down and held in place by cleats. It is suspended by a rope which passes through a pulley at the top and is fastened to a cleat at the side near the roof. The cut also shows two iron eyes, bolted into the front joist of the building, to which the hitch is made when the building is moved.

A rear door, identical in size with the front door, is held in place by cleats nailed across it on the inside and by buttons fastened on the outside. This door is not opened regularly, but provides ventilation in summer and aids in handling sows at farrowing time. Above the rear door is a small sliding door, 8 by 12 inches, to admit light and air.

Another important feature of this house is the ventilator, which is a small cap covering a hole at the top and the center of the roof. The hole is made by sawing off opposite ends of two roof boards and covering it with a cap so arranged as to leave openings 3 inches by 12 inches on each side of the roof. This is sufficient ventilation for two or three animals when all the doors are shut, and if more ventilation is desired it can easily be secured by opening the small sliding door in the rear. This simple plan of ventilation avoids any direct drafts upon the animals and proves very efficient.

With these improvements the cost in building the A-shaped house is somewhat increased. All the boards except those used for the floor should be dressed on one side.

The following lumber is necessary to construct this portable house as shown in figure 2: Nine pieces 1 by 12 inches, 16 feet long, and 11 O. G. battens 16 feet long, for roof, 6 pieces 1 by 12 inches, 14 feet long, for ends; 1 piece 2 by 4 inches, 10 feet long, for ridge, 2 pieces 2 by 8 inches, 10 feet long, for plates; 7 pieces 2 by 4 inches, 16 feet long, for rafters and braces in frame; 3 pieces 2 by 6 inches, 8 feet long, for stringers; and 4 pieces 1 by 12 inches, 16 feet long, rough, for flooring.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 335.

RMFUL AND BENEFICIAL MAMMALS OF THE ARID INTERIOR,

WITH SPECIAL REFERENCE TO THE CARSON AND HUMBOLDT VALLEYS, NEVADA.

BY

VERNON BAILEY,

In Charge of Geographic Distribution, Biological Survey.

WASHINGTON:
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1908.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Biological Survey,
Washington, D. C., July 25, 1908.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin a report on the Harmful and Beneficial Mammals of the Arid Interior, more particularly those of the Carson and Humboldt valleys, Nevada. Large tracts of arid desert are now being reclaimed and converted into arable land, rich in agricultural possibilities. Crops, trees, live stock, poultry, and ditch banks in this reclaimed territory suffer from the depredations of certain mammals, and the farmers, many of whom are from remote localities, are not always able to discriminate between friends and foes; nor are they always acquainted with cheap and effective methods of destroying the noxious kinds.

The report comprises a brief account of the commoner mammals of the region, with special reference to their economic status and the best means of destroying the noxious species, and has been prepared as a practical aid to the ranchmen of the arid interior.

Respectfully,

C. Hart Merriam,
Chief, Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

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HARMFUL AND BENEFICIAL MAMMALS OF THE ARID INTERIOR, WITH SPECIAL REFERENCE TO THE CARSON AND HUMBOLDT VALLEYS, NEVADA.

INTRODUCTION.

The great arid valley surrounding the sinks of the Carson and Humboldt rivers in western Nevada is being reclaimed and converted into a rich agricultural area, and its population is rapidly increasing. The settlers who are bringing these lands under cultivation are confronted with various problems connected with the present and prospective relations of the native mammals to agriculture. Farm crops, trees, live stock, poultry, and ditch banks suffer from the depredations of certain species, and in the indiscriminate retaliation that follows the beneficial animals often suffer equally with the injurious. To many of the settlers who have come from remote localities the mammals are strange and their habits unknown.

At the request of the Reclamation Service and some of the resident farmers, the Biological Survey has undertaken to prepare a brief account of such of the common species of the region as are of importance to agriculture, whether beneficial or detrimental, to the end that the farmers may know friends from foes. As will be seen, most of the losses inflicted by the noxious species may be materially lessened, if not altogether prevented.

The rainfall in this region is extremely limited, but an abundance of pure water is brought from the mountains through great canals, which feed thousands of smaller canals and ditches, extending in an elaborate network among the farms. Many of the ditches are above the general level, and when they are tapped by the burrows of small rodents the water escapes and quickly cuts out the banks. At first the breaks along the canals and ditches were so frequent and serious that a daily patrol was required to avoid expensive repairs. Moreover, as farms are opened up and fields planted, many of the crops and trees are injured by rodents, while poultry, if unprotected, is in danger from nocturnal prowlers. On the other hand, a number of birds and mammals prey almost exclusively on some of the most injurious rodents and insects.

The principal harmful mammals are pocket gophers, meadow mice, ground squirrels, chipmunks, muskrats, kangaroo rats, white-footed mice, harvest mice, house mice, pocket mice, and several species of rabbits. Sometimes coyotes, foxes, and bobcats are very destructive and sometimes very beneficial. The mainly beneficial mammals are badgers, weasels, common skunks, little spotted skunks, grasshopper mice, and several species of bats.

While only those mammals common in the Carson Sink and Humboldt valleys are treated in detail in the present account, most of these species inhabit also other valleys of Nevada, western Utah, southern Idaho, and southwestern Oregon, or nearly the entire sagebrush valley region of the Great Basin. A brief description and an account of the habits of each species is given, with recommendations for the destruction of the injurious and the protection of the beneficial.

GROUND SQUIRRELS.

About a dozen species of small ground squirrels inhabit the arid interior of the western United States, and one or another is found in almost every valley. In many of the irrigated and fertile valleys they do serious injury to crops, and sometimes their burrows are a menace to banks of irrigation ditches. In the aggregate the annual losses to farmers and fruit growers in the United States from the depredations of ground squirrels have been estimated at $10,000,000.

The habits of the small desert species are very similar, and the following directions for the destruction of the Piute ground squirrel apply equally well to most of them.

PIUTE GROUND SQUIRREL.

(*Citellus mollis.*)

These short-tailed, plump little ground squirrels are plain gray without distinctive markings. They are about 6½ inches long to the tail, which adds 1½ inches to the length. They range over much of the valley country of Nevada, western Utah, southern Idaho, and eastern Oregon, at times becoming extremely numerous in certain valleys and causing great damage to crops. They burrow in the fields and meadows, where their shrill little whistle is often heard. In late summer or early fall they become very fat and retire to their burrows to hibernate, not reappearing until early spring. They feed not only on seeds, including grain, but very extensively on green vegetation, and show a partiality for such crops as alfalfa, clover, and many garden vegetables. They also eat insects to a limited extent. When present in their usual numbers they are of little consequence, but occasionally they become so excessively numerous as to destroy almost the whole crop in one or several valleys. It is not difficult to shoot, trap, or poison them over a limited area, but when the area infested is extensive, the work of destroying them means a heavy expense. At certain seasons they are readily killed by scattering poisoned grain among their burrows, but when green vegetation is abundant they do not care for dry grain, and some other method of poisoning must be employed. At such times it is probable that they can be destroyed by means of poisoned alfalfa, melon rinds, turnips, beets, green corn, or other vegetable, or with fresh meat (as they greedily devour each other when caught in traps); but further tests must be made before positive recommendations can be given. Their burrows are usually single and not very extensive, and the animals are readily killed by pouring a tablespoonful of bisulphide of carbon on a ball of dry horse manure or other absorbent, rolling it down the burrow and closing the entrance. A pailful of water poured into the burrow will usually bring out the occupant choking and dazed, when it may be easily caught or killed. In this way Indian boys secure great numbers for food. The animals are really tender and delicious, more delicate than any of the tree squirrels, and equally well flavored. Their habits are cleanly, and there is no valid objection except their small size, to their use as food.

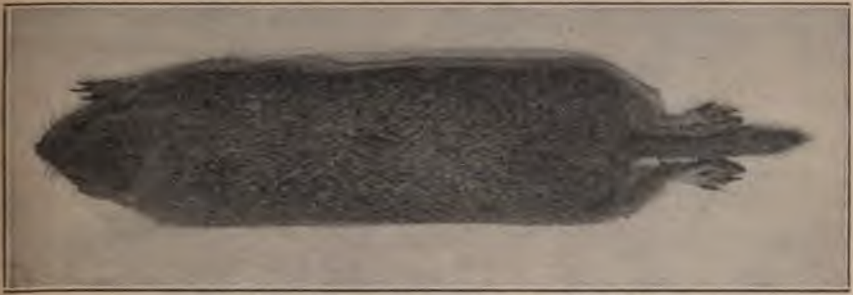

FIG. 1.—Piute ground squirrel (one-half life size).

Directions for poisoning.—For poisoning these and other ground squirrels, chipmunks, rats, and mice the following preparation is recommended by S. E. Piper, after numerous tests in the field:

Dissolve one ounce of strychnia sulphate and 2 ounces of borax in 2 quarts of hot water in a closed vessel, stirring occasionally for twenty minutes, or until completely dissolved. Then add 6 quarts of warm water, and sprinkle this poisoned solution over 30 pounds of rolled or crushed wheat, stirring and mixing thoroughly until it is all absorbed. Place a quarter of a teaspoonful of the poisoned grain near the entrance of each occupied burrow, or in each runway. For mice half an ounce of strychnine is sufficient.

Green alfalfa poisoned with strychnine has given the most satisfactory results in field experiments made by S. E. Piper on this and other ground squirrels. It may be prepared as follows: Dissolve 1 ounce of strychnia sulphate in 1 gallon of hot water. Sprinkle this, when cool, over 35 pounds of freshly cut young alfalfa. Young shoots 3 to 5 inches long are the best, but larger plants may be chopped to the required size. Mix and stir until the liquid is absorbed. Scatter the poisoned alfalfa among the burrows and on the feeding grounds of the squirrels at evening, to be eaten early in the morning before it is withered by the sun. Directions for the preparation of strychnine and chopped alfalfa hay are given on page 12.

ANTELOPE SQUIRREL.

(*Ammospermophilus leucurus.*)

The antelope squirrel is a little larger and stouter than the chipmunk, and unmistakably marked by the short, wide tail, curled over the rump so as to show the white undersurface to the greatest advantage. By means of this conspicuous flag and the dull white stripes along the side of the plain brownish back, together with the short ears and compact form, the little animals are easily recognized even at a distance.

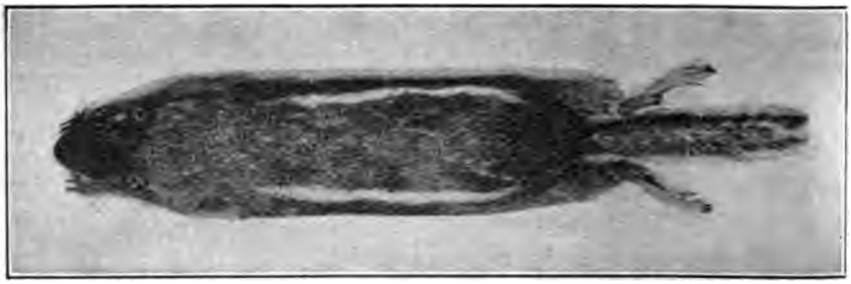

FIG. 2.—Antelope squirrel (one-half life size).

They are characteristic desert dwellers, living mainly on the ground and digging numerous burrows under the bushes and in convenient banks. When seen they are usually running rapidly to take refuge in these burrows or to escape among the bushes. Occasionally one climbs to the top of a sage bush and sits straight up to get a wider view or to bask in the warmth of the morning sun. Their note of alarm or warning is a shrill chatter, but this is rarely heard. Like the chipmunks and other ground squirrels, they are entirely diurnal, and enter their burrows for the night soon after sunset. Fortunately they are not usually numerous and, except rarely when they gather along the edges of fields and feed on grain, do little harm to farm crops. They are fond of many kinds of grain and seeds, and also feed to some extent upon insects. In the ditch banks, however, they are likely to prove serious pests, as they are especially fond of burrowing into any slightly elevated ground. Their burrows are frequently extensive, often going in one side of a ditch bank and coming out the other, near or even below the water line. Fortunately they are easily destroyed by shooting, trapping, or poisoning. It is necessary only to scatter a little poisoned grain near their burrows or along banks and under the bushes where they run to effectually reduce their numbers. For preparing poisoned grain, see page 7.

CHIPMUNKS.

Most of the chipmunks of the western United States inhabit mountain or forest country, but a few of the smaller species abound in the open valleys, especially where sagebrush affords protecting cover. In some of the National Forests they have proved a great nuisance by digging up and eating planted seeds of sugar pines and other conifers. When they gather in sufficient numbers about ranches and along the edges of fields, they often dig up the newly planted or sprouting seeds, and later make serious inroads on the ripening grain. In such cases, they are readily destroyed by scattering poisoned grain along their runways or on their feeding grounds. Directions for the preparation of poisoned grain are given on page 7.

SAGEBRUSH CHIPMUNK.

(*Eutamias pictus.*)

These, the smallest and sprightliest of all our chipmunks, inhabit the valleys, where they are readily distinguished from the ground squirrels by their sharp ears, long slender tails, and striped backs, there being five dark and four light stripes along the back. The length from tip of nose to base of tail is about 4½ inches. The tail is about 3½ inches long.

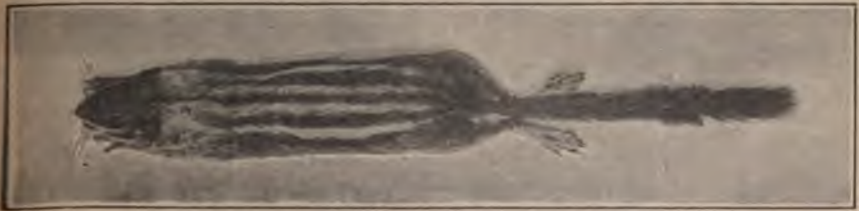

FIG. 3.—Sagebrush chipmunk (one-half life size).

They live mainly in the sagebrush, climbing rapidly through the branches of these diminutive tree-like bushes, as the large chipmunks do through the branches of real trees, or scampering across bare sandy spaces from one bush to another. They often sit on sagebrush tops, eating the little seeds, which they hold in their hands. Their food consists in small part of insects, especially the tiny caterpillars that infest the sagebrush, but is mainly the seeds of sagebrush and numerous small plants that abound on the desert. All cultivated grains are eaten, and in places where great numbers of chipmunks gather along the edge of a field they seriously damage growing crops of wheat, oats, and barley. Except rarely and on limited areas their depredations need not be feared, however, and it is a simple matter to reduce their numbers sufficiently by scattering poisoned grain along the fences or edges of fields where they congregate. They live in burrows in the ground, which they either dig for themselves or appropriate from other more industrious animals, but are not extensive burrowers, and are not likely to interfere seriously with ditch banks. They do not hibernate, but are active throughout the year, and are constantly preyed upon by hawks, owls, and small carnivores.

MEADOW MICE.

Many species of meadow mice inhabit the meadows and stream banks of the western mountain slopes; others, the moist land in the valleys; while still others choose dry fields or arid sagebrush mesas. In habits the various species differ widely, but those that occupy agricultural land are sure to damage crops, and where sufficiently numerous, they become one of the most serious of mammal pests. A recent study of a destructive plague in Humboldt Valley has thrown much light on the practical methods available in dealing with these rodents, and the methods recommended for their destruction will apply to most species of meadow mice.

CARSON MEADOW MOUSE.[a]

(*Microtus montanus.*)

The Carson meadow mouse, black meadow mouse, field mouse, or bear mouse is a stout little animal about 5 inches long to the tail, which is about 2 inches. The short ears are almost hidden in the long, fluffy fur, and the whole color often gives the effect of dull black. Upon close examination the upper parts are found to be dark brownish or grayish and the under parts and feet a lighter shade of gray.

These little animals inhabit naturally the marshes and tule borders of the lakes and streams, but as fast as the country settles up push their way into meadows and fields. They make their homes in the ground wherever a supply of food is found, and are particularly fond of burrowing into the banks of ditches. They take to the water readily, are good swimmers and divers, and therefore can not be drowned out of irrigated fields, as many other small rodents can. Flooding their burrows causes them only temporary inconvenience, as they readily swim to the nearest cover and return as soon as the water disappears. They build warm nests of grass under the cover of fallen vegetation or in underground burrows, where the young are produced and raised in comparative safety. They are very prolific, breeding several times a year and raising litters of 5 to 8 young. Their food consists mainly of green vegetation, of which alfalfa and clovers are preferred to all else. They eat all kinds of grain and seeds or growing vegetables, and are especially fond of potatoes, beets, and other root crops, which they reach by burrowing along the row from one plant to another. Under normal conditions, when living on wild grasses and plants and preyed upon by a host of enemies, these mice do comparatively little damage. Under other circumstances, however, with few enemies and an abundance of rich food, as alfalfa and cultivated crops, and under the protection of dense vegetation, they become so excessively numerous as to completely destroy the crops over wide areas. In certain alfalfa fields in the Humboldt Valley in 1907 their numbers were estimated at 12,000 to the acre. Here the alfalfa was completely destroyed, even the roots being eaten. As a consequence, not only was the crop of the year ruined, but also the crop of the following year. The loss was further increased by the expense of plowing and reseeding the land. Moreover, in winter, when other green food is scarce, these mice attack trees and bushes, eating the bark from fruit trees and even large cottonwoods until they are completely girdled and killed.

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[a] A report on these mice, with full directions for their destruction, by S. E. Piper, of the Biological Survey, is about to be published.

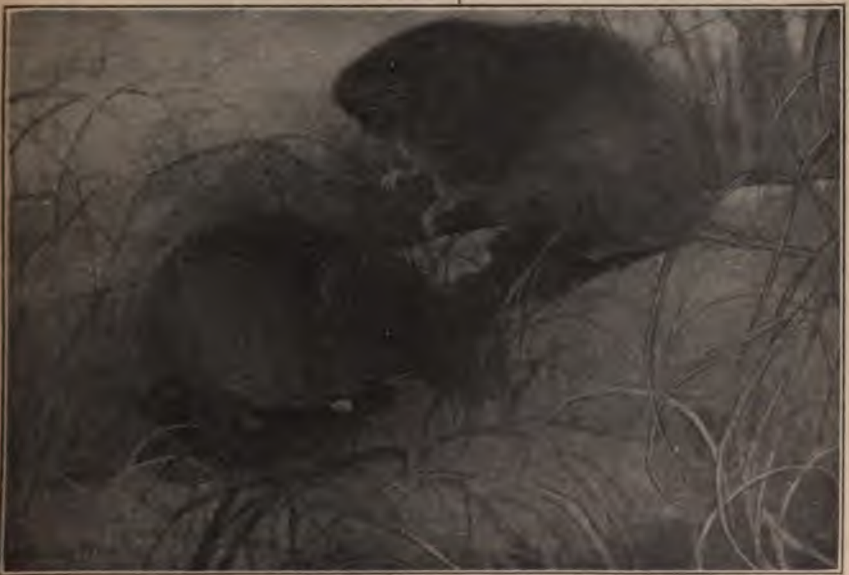

FIG. 4.—Carson field or meadow mouse.

After field mice have become numerous any method of destroying them is expensive. They can readily be poisoned, but this entails great expense for poison, materials, and labor. Preventive measures are much less expensive and far more effective.

It should not be forgotten that the enormous increase of the mice is largely due to the destruction of their natural enemies—hawks, owls, gulls, herons, crows, ravens, magpies, shrikes, and such carnivorous mammals as coyotes, foxes, badgers, skunks, and weasels. Many species of snakes also help materially to keep down their numbers. As far as possible these natural enemies should be protected and allowed free access to the fields and open country. Weedy or grassy fence rows and border lines should be closely mowed to give these industrious allies of the farmer every advantage in capturing the mice, and after each cutting of a crop they should be made welcome to the stubble fields.

Meadow mice do not hibernate, but are busy throughout the year, and about equally active during the day and night. Fortunately, however, they do not continue to breed during the winter months, and by energetic measures their numbers can be so reduced before the next breeding season that there will be little danger to the following crop. If undiminished numbers are left over winter to begin breeding in the spring, the crop for that season is doomed.

Directions for poisoning.—Where mice are increasing it may be necessary to resort to summer poisoning with a preparation of strychnine and wheat or barley distributed around the borders of the fields;[a] but the winter, or from November to April, when green food is scarce, is the most effective time of year for destroying them. Piper has found that then they may be poisoned most effectively and economically with a preparation of chopped alfalfa and strychnine prepared as follows:

Dissolve 1 ounce of strychnia sulphate in 2 quarts of hot water, then add 5½ gallons of water. Sprinkle this over 30 pounds of finely chopped alfalfa hay or alfalfa leaves from the bottom of stack or haymow, mixing and stirring thoroughly until the liquid is evenly absorbed by the hay. Place a small pinch, or about a teaspoonful, of this material at the entrance of each occupied burrow.

MUSKRAT.

(*Fiber zibethicus.*)

Muskrats are too well known to need description, for what country boy has not trapped them for the sake of their brown, furry coats and carried them home by their flattened and naked tails? They are common along the streams and larger ditches and in the marshes and tule swamps of the Carson Sink and Humboldt valleys, as over most parts of North America. They rarely leave the stream banks

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[a] For preparation of poisoned grain see p. 7.

's edge or do serious mischief to crops; but where, as often the banks of irrigation ditches are elevated above the gen- l, they are a source of considerable danger. Their burrows nter the banks a foot or two below the water line and extend iderable distances, sometimes penetrating the whole width bankment and causing expensive breaks and the flooding of crops. Muskrats are easily trapped, however, and when in time they can be caught and the mischief prevented. In ith elevated banks permanent traps can be placed at the two uch a manner as to impound any muskrat attempting to enter . These traps should be made of woven-wire netting in the cage, either reaching across the ditch or placed in the middle itch with wings extending to both banks. A funnel-shaped with pointed wires sloping inward around the margin of the should be set at the water level on each side of the cage, the animals to enter from either side, but not to return. ractically the fyke net used for catching fish. If caught fur is good, the pelt will pay for the trouble, and when the t marketable the animals can readily be transferred to an pond or stream until it is of the highest market value. Musk- be poisoned along ditch banks by means of strychnine or n carrots, parsnips, or turnips; but this is an unnecessary a valuable animal; besides the dead bodies pollute the There is danger also that the poisoned vegetables placed for ng the banks would float downstream and be eaten by farm

SHORT-TAILED GRASSHOPPER MOUSE.

(*Onychomys brevicaudus.*)

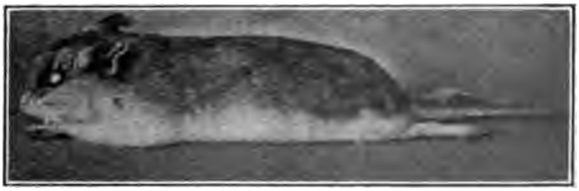

FIG. 5.—Short-tailed grasshopper mouse (one-half life size).

rasshopper mouse most resembles the common white-footed mouse, but r and more ctly built, orter ears ort, thick, tail. Its under parts white, while r parts vary from buffy gray to a pale ashy gray. A full- dividual measures about 4 inches to the tail, which is only inch and a half long.

grasshopper mouse is common throughout the sagebrush f the Great Basin country, but is one of the least known and ely seen of the many desert species. It is strictly nocturnal r comes into or around buildings. At night it prowls among the desert bushes, capturing grasshoppers, mole crickets, and many other insects, and also scorpions. It occasionally catches and devours other species of mice, and will even turn cannibal and eat its own kind when caught in traps. It also occasionally eats a few seeds, and usually will take rolled oats when used for trap bait. The only practical way to secure specimens of these mice or to get at all acquainted with their habits is by trapping them. At night their presence is often made known by a fine, prolonged whistle, so sharp and shrill as to suggest the sound produced by some insect. Apparently grasshopper mice are never very abundant, but they are so widely distributed that they serve as an effective check on the increase of certain kinds of insects. When captured alive they are usually perfectly tame from the first and make extremely interesting pets. It would doubtless be possible to keep and breed them in confinement and make them of use in ridding gardens or greenhouses of insect pests.

WHITE-FOOTED MICE.

The white-footed mice, deer mice, or wood mice, are abundant, both in species and individuals, over most parts of North America, and especially numerous in the arid region of the western United States. Usually several species occupy the same ground, and one or more adapt themselves to almost every condition of climate and environment. Sometimes they become serious pests, but usually they are so preyed upon by a host of enemies that their numbers are kept within bounds. Besides destroying some grain in fields and stacks, they often enter buildings and do considerable damage, especially in newly settled regions. Most of the species are nocturnal and have somewhat similar habits.

SONORAN WHITE-FOOTED MOUSE.

(*Peromyscus sonoriensis*.)

The Sonoran white-footed or deer mouse is a bright little animal about 3½ inches long to the tail, which is about 2½ inches. Its feet and under parts are pure white, while the upper parts are clear gray or light buffy gray. Its large ears and bright black eyes give it a very animated and attractive expression. It is abundant over the whole valley country of the Great Basin and far beyond.

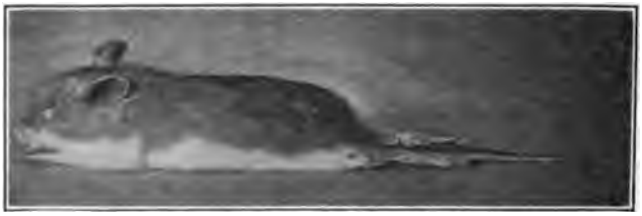

FIG. 6.—Sonoran white-footed mouse (one-half life size).

Though strictly nocturnal, these mice are often seen because their homes are in hollow logs, under brush heaps, in hay stacks, under shocks of hay or grain, or in and around buildings. In a new country they frequently enter houses, and sometimes become as troublesome as house mice. They make nests in clothing or blankets stored away in bureaus and boxes, and if a house is left vacant they make their nests in the beds, cutting blankets and mattresses for nesting material. Their usual food consists mainly of small seeds, berries, and a few insects, but they are almost as omnivorous as house mice, and are fond of most provisions which pantry or cellar affords. They are readily poisoned, or they may be caught in small traps, and premises once cleared of them are not soon infested again.

In fields they can be readily destroyed by means of poisoned grain, but great care should be taken to place the poison out of reach of poultry. Around fields and in the open country these mice are constantly preyed upon by many species of owls and hawks, by a number of carnivores, such as coyotes, bobcats, foxes, weasels, badgers, and skunks, and by many kinds of snakes. The only danger of their becoming a serious pest is through the destruction of their natural enemies.

CLIFF MOUSE.

(*Peromyscus crinitus.*)

The cliff mouse differs from the Sonoran white-footed mouse in having a much longer tail and larger ears. Its head and body measure about 3¼ inches, the tail 3¾ inches. It inhabits rocky places, especially cliffs along rocky canyons. It is not usually found n the open valley and is therefore of little economic importance.

LARGE-EARED MOUSE.

(*Peromyscus truei.*)

The large-eared white-footed mouse is considerably larger than the Sonoran or cliff mouse, measuring about 4 inches to base of tail, the tail 4½ inches. It inhabits canyons and rocky hills along the sides of valleys and rarely comes into the open country.

HARVEST MICE.

The several species of harvest mice inhabiting the arid valleys of the western United States are very similar in appearance and habits. They are among the smallest of our rodents—dull-colored, inconpicuous little mice—and, though often very numerous, are rarely een.

DESERT HARVEST MOUSE.

(*Reithrodontomys megalotis deserti.*)

The desert harvest mouse is a tiny animal about 2½ inches long to the tail, which is about 2¾ inches. Its under parts are light gray and the upper parts dull buffy gray; the ears are prominent and thin; but the unmistakable character by which it may be known is the deep groove down the front surface of each upper incisor.

It inhabits fields, dry meadows, and grassy or weedy places generally, but never comes near buildings or makes itself a nuisance. It builds rounded grass nests in the fields under cover of protecting vegetation or under shocks of grain and hay. It is active both day and night. Tiny paths or runways may be traced from one nest to another or from the nests into the fields and over the feeding grounds. The animals feed mainly on small seeds, grain, and a little green vegetation. When in usual numbers they are of no serious consequence, but when, as occasionally happens, they become very abundant the tax which they levy on grain and sprouting seeds means in the aggregate a considerable loss. To attempt by artificial means to destroy a horde of such tiny animals would be like fighting a plague of grasshoppers. But nature has provided numerous enemies, such as hawks and owls, weasels, and other carnivorous mammals, and many snakes, that constantly prey on them by night as well as by day.

HOUSE MOUSE.

(*Mus musculus.*)

The house mouse is too well known to need description. The only native species with which it can be confused is the harvest mouse, from which it may be readily distinguished by its larger size and by the plain or ungrooved upper incisors. Although a native of the Old World, it follows civilization so closely that it soon becomes established in any newly settled region. It first invades houses and ranch buildings, but in the mild climate of the Nevada and Utah valleys quickly spreads to the fields, where it becomes a permanent and more or less destructive resident. It usually follows the edges of grain fields, and makes its home in burrows in ditch banks or under weeds along fences. Sometimes house mice become so numerous about fields as to destroy much of the standing grain. They also quickly take up their abode in shocks of grain or in stacks, and if these are left standing for a long time, the quantity of grain eaten and wasted is correspondingly large. The habit of keeping under cover partially protects them from the attacks of hawks, owls, and predaceous mammals, and it is often necessary to destroy them about outbuildings and stacks by artificial means. This can readily be done by trapping or by scattering poisoned grain in places infested by them, placing the grain in slight excavations under boards or in drainpipes to keep it from larger animals. Where the mice range into the open country and fields, they are preyed upon by natural enemies, and can not be controlled better than by protecting hawks, owls, weasels, badgers, skunks, and snakes.

COMMON OR BROWN RAT.

(*Mus norvegicus.*)

The common rat is an introduced species which follows closely the settlement of a new country and becomes a more or less serious pest according to circumstances. In sparsely settled regions it is rarely very troublesome, but as settlements increase and the land is cultivated more closely, rats thrive and multiply until they become most destructive. At first their mischief is confined to houses, stables, and outbuildings, where the amount of grain, provisions, and poultry destroyed is often considerable, but later they often spread into the fields and destroy crops. The danger from contagious diseases, which are conveyed from port to port and from house to house by rats, is in itself sufficient ground for relentless war upon these filthy and disgusting rodents. In Farmers' Bulletin 297, Methods of Destroying Rats, detailed directions for the destruction of rats and mice will be found. The simplest of these methods is poisoning with a preparation of strychnine and grain or using a trap that kills the rat instantly. One of the best baits is a bit of smoked Vienna sausage. When poisoned grain is used, it should be placed in well concealed situations, such as runways covered with boards, or in tin cans, drainpipes, or some kind of tubing that will admit the rats but no larger animals. For the preparation of poisoned grain see page 7.

WOOD RATS.

Unlike the introduced brown or wharf rats, the wood rats are natives of this country—a product of the wilderness rather than a parasite of civilization. Some species inhabit the mountain slopes, living mainly among rocks; others occupy timbered or brushy areas, and several are restricted to desert valleys. Usually they build conspicuous houses of sticks, stones, bones, and rubbish, either among rocks or brush or in the open, or in some cases in the branches of trees. They rarely enter occupied buildings and have none of the habits of the common brown rat. In areas where they become unusually abundant they sometimes do considerable damage along the edges of grain fields and vegetable gardens, but they are easily poisoned or trapped at their houses or along their conspicuous runways.

DESERT WOOD RAT.

(*Neotoma desertorum.*)

The desert wood rat is a native of the arid region and is the only species found in the valleys of western Nevada. It slightly resembles the common brown rat, but is readily distinguished by its smaller size, larger ears, softer, silkier fur, shorter, less naked tail, paler color, and the pure white feet and under parts. It measures about 6 inches to base of tail, which measures about 5 inches.

These wood rats are common over the desert valleys of Nevada, both among rocks and in the open sagebrush country, where they build their own houses and live singly or in families. For houses they heap up a bushel or more of sticks, stones, cow chips, cactus, bones, or other materials which the animals can carry and pile up as a protecting cover for their nests and burrows in the ground beneath. Cactus and thorny branches, if available, are always a conspicuous part of the building material. The house is usually occupied by one old rat, a pair, or a family, but never by a colony. Wood rats are social and visit back and forth from one house to another until well-worn trails often connect the houses and lead to the feeding grounds. The food of these animals is mainly seeds, berries, and many kinds of green foliage. Where the houses are located near the edges of fields, grain, fruits, and vegetables are sometimes eaten or carried away and stored up for food, but fortunately the rats are never sufficiently numerous to do serious damage. Their houses are easily destroyed and the occupants captured by a few minutes' work with a shovel, or the rats can readily be trapped or poisoned. They frequently enter cabins or camps not permanently occupied and eat or carry away provisions. They sometimes cause great annoyance by cutting leather harnesses or saddles. There is rarely more than one animal responsible for the mischief in a camp, however, and a rat trap will usually prevent further trouble. It is unfortunate that the odious name of rat has become attached to these bright and interesting little animals, as otherwise they might become a table delicacy. They are cleanly in habits and are strictly vegetarian in diet. Their flesh is as white and delicate as that of the quail and finer in flavor than that of the squirrel or rabbit.

POCKET GOPHERS.

One or another species of pocket gopher inhabits almost every part of the western United States, some ranging above timber line along the crests of high mountains, others occupying the middle slopes, others the humid areas, and still others the bottoms of the hottest desert valleys. Rarely, however, do more than one species occupy the same ground. All are industrious burrowers, living mainly underground and throwing up numerous mounds of earth along the lines of their interminable tunnels. They gather and multiply in the more fertile areas, where green vegetation furnishes an abundance of food, and commit ravages on almost every farm crop. Like the meadow mice and ground squirrels, they rank among the most injurious of rodents in agricultural regions where they occur, and every practical method is sought for their destruction. The annual losses to farmers and fruit growers in the United States from the work of pocket gophers have been estimated to aggregate more than $12,000,000.

NEVADA POCKET GOPHER.

(*Thomomys nevadensis.*)

The Nevada pocket gopher is one of the larger species, measuring about 7 inches to the tail, which is about 3½ inches. Its large fur-lined pockets on each side of the cheeks, long front claws, heavy incisors, small eyes, and inconspicuous ears unmistakably mark the animal. Its tail is slender and almost naked; its soft, glossy fur is of a sandy or pale buffy color above and paler buff or soiled whitish below.

These gophers are abundant in the mellow soil of the valley bottoms, especially in the more fertile parts. They are rarely, if ever, found on the hard; baked soil of the mesa and ridge tops, where a smaller species sometimes takes their place. Where the soil is mellow and food abundant they often become extremely numerous, and their mounds of earth are scattered thickly over the surface of the ground. The animals themselves are rarely seen, as they live almost entirely underground in their interminable burrows, which usually run about a foot below the surface and are extended day by day in search of food. Openings to the surface are made at intervals of a few yards, and the loose earth from the burrows is pushed out in little heaps. After a few quarts, or sometimes a bushel, of earth have been pushed out, the opening is securely closed and packed with earth. Then, as the tunnel is extended, a new opening is made farther along, and another little mound marks the line of progress. Gophers are solitary, more than one rarely if ever occupying a burrow, although from the great number of mounds it is often supposed that they live in colonies. However, in the course of a month a dozen gophers in an alfalfa field will throw up several hundred mounds of earth, which not only cover and destroy much of the crop, but interfere seriously with the mowing machine. At the same time the animals are feeding mainly upon the roots of alfalfa. In many cases the roots are entirely eaten off a plant and the plant killed, while in others they are only partially eaten and the plant more or less injured. Roots are the principal food of gophers, though some green vegetation is eaten. The tunnels are often extended into gardens or fields where almost every kind of vegetable is eaten, but especially potatoes, beets, and turnips. A gopher will follow a row of potatoes, tunneling from one hill to the next and eating the tubers in each hill. Orchards sometimes suffer even more serious harm. A single gopher has been known to destroy the greater part of the fruit trees in a small orchard by eating off the roots of one tree after another.

The most serious mischief, however, is the destruction of ditch banks. Sometimes the animals are forced out of irrigated land and take up new quarters in the dry ditch banks, or in course of the regular extension of their tunnels a ditch is encountered and the bank is followed in search of a crossing place. In either case the burrow is almost sure sooner or later to penetrate below the water line and start a leak that cuts out the bank and empties the ditch. In small ditches the breaks are annoying in proportion to their frequency, but in larger ditches and canals they are far more serious and in places even dangerous.

No animals are more easily controlled, however, on a small farm or along ditches than gophers. They are readily trapped or poisoned, and once cleared out of a field others do not come in at once. Their mode of travel, which is principally by extending their burrows, is of necessity slow; and if occasionally caught or poisoned around the edge of fields or along ditches, they can be effectually controlled. With the proper kind of trap and with a little experience one can catch a large number in a day by repeatedly visiting and resetting the traps in new places as fast as the gophers are caught. With the best kind of guillotine trap it is necessary only to make a clean opening into the burrow and place the trap in the entrance so that the animal in coming out to close the doorway will push through the loop, press the trigger, and be caught around the neck or just back of the front legs. Gophers have been poisoned very successfully by inserting small crystals of strychnine in raisins, prunes, or potatoes, placing the bait well back in the main burrow, and closing the opening. This method may not prove successful with all kinds of gophers, but it is worth trying, as it is the simplest way of disposing of them. For more detailed instructions for trapping and poisoning gophers see Circular 52 of the Biological Survey.

Gophers subsist on the cleanest and most wholesome of foods and when properly prepared and cooked are excellent food, tender and well flavored.

SAGEBRUSH POCKET GOPHER.

(*Thomomys fisheri.*)

This small grayish brown species inhabits the sage-covered mesas and lower mountain slopes, but rarely if ever comes down into the cultivated valleys. It is readily distinguished from the Nevada gopher by its smaller size and more brownish color. In some of the foothill valleys it comes into fields, gardens, and orchards, and does considerable mischief, but in the Carson Sink and Humboldt valleys it is of little economic importance.

POCKET MICE.

The pocket mice of the region under consideration may be recognized by their small size, fur-lined cheek pockets, tiny ears, glossy olive-gray or yellowish coats, and pure white feet and under parts. Of the Nevada species the Great Basin pocket mouse (*Perognathus parvus olivaceus*) is a little larger than the house mouse, measuring about 3 inches to the tail, which measures about 3½ inches. The smaller or Nevada pocket mouse (*Perognathus nevadensis*) measures about 2⅜ inches to base of tail, which is about 2⅞ inches.

The pocket mice are obscure little animals, never numerous, and rarely seen because strictly nocturnal. They live on small seeds which they gather and carry in the cheek pouches to store in the burrows for food, and though occasionally they take a little grain this is never enough to be missed. They burrow in dry ground, generally under the edge of a sheltering bush or in the side of a bank of mellow soil. Their burrows, however, are not very extensive and only rarely are they a source of danger to the banks of the smaller irrigation ditches. The mice are easily caught in small traps baited with rolled oats and placed at evening near the burrows. Unless as the result of a great reduction in the numbers of mouse-hunting birds and mammals, they will never be a pest or cause for serious alarm on the part of the farmer.

KANGAROO MOUSE.

(*Microdipodops pallidus.*)

The kangaroo mice, or elf mice, like the kangaroo rats, have long feet and legs and large heads, but, like some of the pocket mice, have slender, tapering tails. They have fur-lined cheek pouches, big black eyes, short ears, and silky, sandy gray coats and white under parts. They measure to base of tail about 2¾ inches, and the tail about 4 inches.

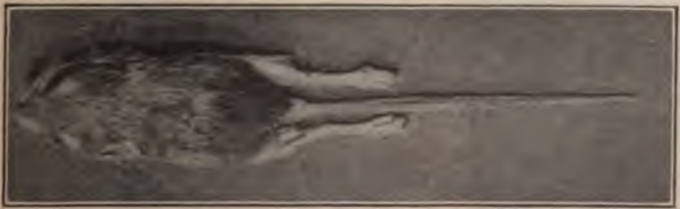

FIG. 7.—Kangaroo mouse (one-half life size).

They are rarely seen alive and comparatively few specimens have ever been trapped. A few have been taken along the eastern edge of the Carson Sink Valley, and probably they are more generally distributed over the sagebrush deserts than is known. They are nocturnal and live in small burrows similar to those of the pocket mice. Though extremely interesting little animals they are so rare as to be of practically no economic importance.

KANGAROO RATS.

Four species of kangaroo rats inhabit the Carson Sink Valley and some of the neighboring valleys. While not even remotely related to either kangaroos or rats, they have been thus named on account of their long hind legs and tails, small hands, and their method of progressing by hops. They are so similar in general appearance that three of the four species can be distinguished only by careful examination or actual comparison of specimens. One species, the desert kangaroo rat, is readily distinguished by its large size, about twice that of the others, and by the white tip to its tail. The three smaller species are almost identical in colors and markings. They have large heads, short ears, large black eyes, and very long, slender tails. In color they are buffy or yellowish gray above and pure white below, with a white stripe across the hip and along each side of the tail. They can be distinguished as follows:

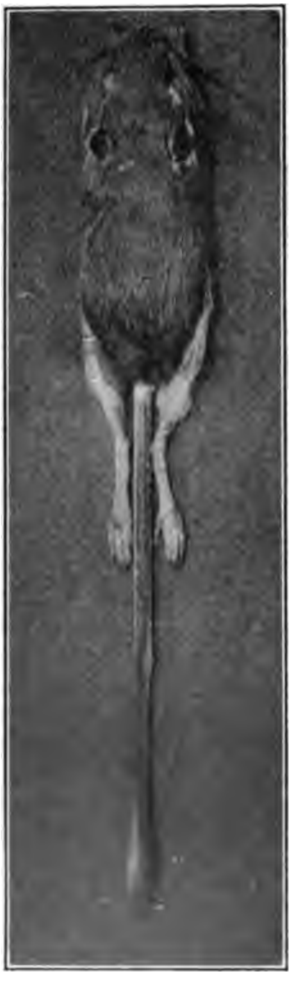

FIG. 8.—Columbia five-toed kangaroo rat (one-half life size).

Hind foot with only 4 toes:
Head and body about 4 inches; tail 5½ inches; hind foot 1½ inches—
Nevada 4-toed kangaroo rat (*Dipodomys nevadensis*).
Hind foot with 5 toes, the fifth very small:
Head and body about 4 inches; tail 5½ inches; hind foot 1½ inches—
Columbia 5-toed kangaroo rat (*Perodipus columbianus*).
Head and body nearly 5 inches; tail 6½ inches; hind foot about 1⅝ inches—
Great Basin 5-toed kangaroo rat (*Perodipus levipes*).

In habits these three little kangaroo rats are as similar as in general appearance, and they seem to be about equally abundant.

They are common over the drier parts of the valley country, especially in the mellowest and sandiest soil. Their burrows are numerous and extensive, and are usually in the side of some slight elevation or embankment, where they are carried back on a nearly horizontal plane. Generally there are several openings to a group of burrows, centering in a den or nest chamber and opening out on opposite sides. Often two connected doorways are 10 or 15 feet apart, and approximately on a level with the central nest chamber. These burrows, if in the embankment of a dry ditch, may readily prove an outlet to the water turned into the ditch, and so cause serious breaks. The animals never become excessively numerous, and the amount of grain which they carry away in their cheek pockets is of little consequence. Small native plants furnish them an abundance of seeds, and these, with a little grain from the fields, constitute most of their food. Along ditches, or wherever it is necessary to destroy them, they may be poisoned by scattering a few grains of poisoned wheat or rolled barley near their burrows. Like all kangaroo rats they are strictly nocturnal, and poison should be distributed in the evening after the seed-eating birds have gone to roost.

DESERT KANGAROO RAT.

(*Dipodomys deserti.*)

This large four-toed kangaroo rat differs mainly in size from the three smaller species. It is about 5 inches from tip of nose to base of tail, and the tail is about 8 inches long. Its legs and hind feet are disproportionately long, in striking contrast to the tiny front feet, or hands. The large head, prominent black eyes, and short ears give the animal a quaint appearance. The glossy coat is light sand color over the upper parts and pure white below. The tail is white along the sides and for an inch at the tip. The fur-lined cheek pouches are large enough to admit the tip of the little finger.

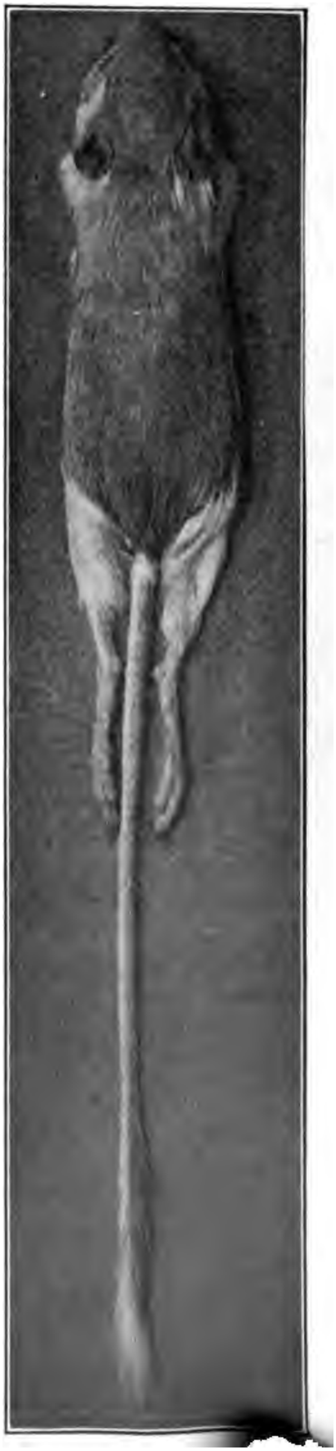

Fig. 9.—Desert kangaroo rat (one-half life size).

These remarkable animals are common among the sand dunes in the bottom of the Carson Sink Valley. They are strictly nocturnal and are rarely seen alive, but their big round burrows are conspicuous, and the paired tracks of their long hind feet may be seen every morning on the naked sands. The tiny front feet are used only as hands and do not figure in the tracks. The manner of traveling is by hops, or long leaps on the hind feet, while the tail serves as a balance and rudder, hence the name of kangaroo rats. In habits they are practically identical with the three smaller species of kangaroo rats occupying the valley, but their larger burrows, often 3 or 4 inches in diameter, are always recognizable. The burrows usually enter the side of a sandy hillock, dune, or embankment, and often extend 10 or 20 feet in a nearly horizontal direction. They do not go deep into the ground, but if started at the base of an embankment they may penetrate through far below the water level and tap the ditches. The partiality of these animals to mellow soil often tempts them to begin burrowing in newly made embankments, but being true desert animals, with a great aversion to water, their mischief is entirely accidental. Their food consists mainly of the small seeds of native desert plants, but also includes a little grain. A part of the food is carried into their burrows for future use. They are never sufficiently abundant to seriously injure crops. Usually on entering the burrow before daylight in the morning they securely close the opening behind them by packing it full of fresh sand, doubtless to keep out snakes, weasels, and other unwelcome intruders. As they rarely come out of their dens until after dark, their presence often remains unknown to people living in the country. They are easily caught in rat traps set near the entrance of thē burrows with a little rolled barley or oats scattered over the trigger of the trap. In localities where there is danger of their injuring ditches they can be readily poisoned by scattering a little poisoned grain near their burrows.

RABBITS.

The rabbits of the arid interior of the western United States comprise the black-tailed jack rabbits, the white-tailed jack rabbits, the cottontails, and the brown-tailed pygmy rabbits (*Lepus idahoensis*). Of these the cottontails and the black-tailed jack rabbits are the most abundant and generally distributed in the desert valleys, and the most injurious where they come in contact with growing crops.

BLACK-TAILED JACK RABBIT.

(*Lepus deserticola.*)

The black-tailed jack rabbit of the valleys is readily distinguished from the large white-tailed jack rabbit of the neighboring mountains. It may be known at all seasons by its very long ears, which black upper surface of the tail, and light gray coat. It is a desert valley animal of wide distribution.

While at home in the desert and at long distances from water, these rabbits prefer the fertile valleys, and often gather in great numbers to feed upon alfalfa, growing grain, melons, vegetables, or young fruit trees. They often become so abundant as to threaten the destruction of crops, and it becomes necessary to destroy them. Rabbit drives have been organized in different parts of the West and great numbers of rabbits surrounded, driven into corrals, and killed. Many thousands have been thus destroyed in a single drive. Except when they are very numerous, however, this method is not practical. Furthermore, it is often important for a farmer to destroy the few rabbits that regularly visit his fields, gardens, or orchards. Sometimes this can be done by shooting, but rabbits may readily be poisoned by means of strychnine in sugar beets, melon rinds, or pieces of apple placed along their runways. The use of poison is always attended with danger, however, and care should be taken to place the poison where no other animals can get at it.

A strong prejudice against eating jack rabbits often exists because occasional individuals are infested by such parasites as the "warble" or "grub" and the tapeworm larva. Unless badly affected, however, the flesh is not injured by these parasites, and there is no good reason why the animals should not be extensively used as food. The half-grown or nearly full-grown young of the year are usually healthy and very good eating when properly cooked. Those not needed for the table may be fed to dogs and poultry. For dogs they should be cooked. The principal natural enemies of jack rabbits are coyotes, foxes, bobcats, hawks, owls, and eagles. When rabbits become abundant these enemies gather to feast on them, and then at least should be afforded protection.

COTTONTAIL.

(*Lepus nuttalli.*)

The cottontail rabbit of the Nevada sage plains is a small light-gray species with moderately long ears. It is easily distinguished from the much smaller, shorter-eared, and almost tailless *Lepus idahoensis* of the higher sagebrush valleys to the east and north.

Cottontails are fairly common throughout the valleys, especially where there is abundant cover of dense sagebrush and greasewood to protect them from their numerous enemies. They are so persecuted by birds of prey and carnivorous mammals that they rarely become sufficiently numerous to do serious mischief. When, as occasionally happens, they do become numerous, they are especially injurious to young orchards. Under the protection of hedgerows and weedy ields, they enter nurseries and orchards and cut off the young trees or eat the bark from the larger trees. Sometimes in the winter, when green food is scarce, two or three rabbits will almost destroy a small nursery or orchard. Where rabbits can not readily be shot, snared, or trapped, they may be destroyed over limited areas by means of poison. A few small crystals of strychnine should be inserted in pieces of sweet apple or cabbage leaf, and these pieces impaled on stakes 2 or 3 inches above the surface of the ground along the runways. Another method of poisoning, much safer and almost as effective, is to soak the twigs of apple or pear trees in a strychnine solution and scatter them along the rabbit trails. Rabbits may be kept out of an orchard, however, by means of an 18-inch strip of light woven wire along the bottom of any ordinary fence. This wire should cost not more than 15 or 20 cents a rod. When necessary, each tree may be protected by means of an 18-inch strip of woven wire at the bottom or by wrapping with thin wood veneer, paper, or sections of cornstalks. When the orchard is small, these methods are simple and inexpensive. Even were it possible, it is not desirable in any locality to exterminate cottontails. When few in number, they are practically harmless, and they furnish an important article of diet at almost all times of year. Young rabbits are especially delicious.

BOBCAT.

(*Lynx baileyi.*)

The bobcat, or wild cat, is the only native cat in the valley country. From the Canadian lynx of the high mountains it is readily distinguished by its smaller size, much smaller feet, more spotted coat, and the small size of the black mark on the tip of the tail, which is confined to the upper part of the tip. In the Canada lynx the whole end of the tail is black.

The favorite home of the bobcat is the rocky canyons of the low mountains and foothill country, but individuals frequently wander across the widest desert valleys and are at home anywhere in the sagebrush or thickets along streams. They find abundance of such food as rabbits, ground squirrels, gophers, mice, and woodrats, but they kill sheep also, and sometimes visit the henhouse at night. Except for the destruction of sheep and poultry they may be considered almost entirely beneficial in their relations to agriculture, but occasionally their depredations about ranches are so serious that it is necessary to destroy them. There is no excuse for leaving poultry where accessible to such animals at night; hence the destruction of sheep is the most serious charge against them. Bobcats are readily caught in steel traps baited with rabbits or bits of rabbit fur scattered around a well-concealed trap, or they may be captured by dogs at night. They are not readily poisoned.

DESERT FOX.

(*Vulpes macrotis.*)

The desert fox closely resembles the swift or kit fox of the Great Plains region, but has conspicuously larger ears. It is a slender, graceful little animal of a pale yellowish-gray color, with a black tip to its bushy tail. It inhabits the desert valleys to the south, and apparently reaches its northern limit in the Carson Sink Valley, where it is by no means common.

These foxes are so shy and cunning as to be rarely seen in daytime, but at night they often come boldly into camp and help themselves to meat or game left within their reach. Their principal food, however, is kangaroo rats, ground squirrels, gophers, and mice. I have never known them to molest poultry, and consider them mainly beneficial.

COYOTE.

(*Canis lestes.*)

Coyotes are the commonest, best known, and most widely distributed of the larger carnivorous animals of the West. They are readily distinguished from dogs, even at a distance, by their erect and pointed ears and drooping tail. Still more unmistakable is their combination bark and howl, a kind of *yap-yap ki-yi-yi-yi-yi*, which once heard is never forgotten. Though natives of the plains and deserts, coyotes thrive in agricultural regions, and show a tendency to increase rather than decrease as the country becomes more thickly settled. They are bold and cunning, defying the ranch dog and prowling at night through pastures and fields and about corrals and barnyards, where they pick up any dead animals left within their reach, or capture unprotected poultry, lambs, or sheep. They are such bold freebooters that they prove a constant annoyance to the farmer, though usually causing him no very serious losses. Their worst crime is the destruction of sheep on the stock ranges, which, in some States, causes a loss amounting to several hundred thousand dollars annually. A small flock of sheep is most easily and economically protected by a coyote-proof fence. The expense for materials for such a fence need not exceed 50 to 75 cents per rod. Full directions for construction are given in Circular 55 of the Biological Survey.[a] When farm stock is thus protected the coyote becomes a useful ally of the farmer, as his natural prey consists mainly of rabbits, ground squirrels, gophers, rats, mice, some of the larger insects, and a little fruit. In many cases where rabbits and mice have become so excessively numerous as to destroy the crops, coyotes have gathered from all sides and proved of great value in destroying these pests. Under such circumstances they should be at least temporarily protected.

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[a] Directions for the destruction of wolves and coyotes. Circular 55, Bureau Biological Survey, U. S. Department of Agriculture.

SKUNKS.

Skunks are among the most useful of our carnivorous mammals, though often destroyed in the belief that they are injurious. There are two widely different kinds—the large skunks (genus *Mephitis*) and the small spotted skunks (genus *Spilogale*).

LARGE SKUNK.

(*Mephitis major.*)

The large skunk with two white stripes on the back is common throughout the valleys of northern Nevada and Utah, and if protected as it deserves would be far more common. Usually they live within reach of water and follow lake shores and small streams and ditch banks, where mice are most abundant, and make their burrows and breeding dens in thickets or in the sides of gulches. They dig industriously for mice and small rodents, and in this way may occasionally injure ditch banks, but on the whole their work is beneficial. Their food is mainly insects and small rodents, with occasionally a little fruit, and more rarely some unprotected poultry. Grasshoppers, crickets, beetles, and beetle larvæ often make up the main part of their food, but mice, gophers, and small rodents are captured in considerable numbers. At times, when mice become excessively numerous, skunks feast upon them almost exclusively. With a little care the farm poultry can be effectually protected and the skunks left free to carry on their useful occupations. They do not climb, and a 2-foot strip of woven-wire mesh across the bottom of the henhouse door will effectually bar them while allowing the free entrance and exit of the poultry. A still better plan is to inclose the poultry house and yard with a fence that will keep out not only skunks, but foxes, coyotes, badgers, cats, and dogs. Wire netting (1 or 1½ inch mesh), if brought close to the ground and supplemented by a closely barbed wire just under the surface, should prove effective against all of these animals. The fence need not be over 4½ or 5 feet high, unless to keep in fowls that are inclined to fly out.

LITTLE SPOTTED SKUNK.

(*Spilogale saxatilis.*)

The little spotted skunks are about half the size of the common skunk, but instead of two diverging white stripes on the back they have numerous narrow stripes and spots extending from the neck to the rump. Their weapon of defense is similar to that of other skunks, but their habits differ in many particulars. Spotted skunks are partial to cliffs and rocky canyons, but occasionally wander across the valleys and may be found anywhere in the sagebrush or about fields or along streams. They climb trees readily and are sprightly and weasel-like in their motions. Their food consists largely of mice, though many insects and some fruit and occasionally a bird are eaten. Where rocks and crevices are not available they live in burrows, often in the banks of streams or washed-out gulches. Except when digging after mice and small rodents they are not likely to injure ditch banks and, like other skunks, are almost entirely beneficial.

BADGER.

(Taxidea americana.)

Formerly the badger was common over all the desert valleys of Nevada, and might often be seen trotting along the roadside or lumbering hurriedly to take refuge in the nearest burrow. Almost the whole life of the badger is spent in digging out the various rodents that constitute its food. It requires two or three fat ground squirrels a day, or a few gophers and a dozen mice, to keep a badger in good condition. With his long claws and powerful front legs he quickly digs out the burrow of any small rodent, and unless the burrow has a back door the occupant is at his mercy. In case of pocket gophers the badger digs down in several places along the line of the burrow and sometimes succeeds in cornering and capturing the occupant. Mice are easily unearthed, and a nest of young mice is a special delicacy. A few insects are eaten, and on rare occasions a badger gets into a henhouse and makes a meal of poultry. This is the only sin ever laid to his charge, except that his big burrows occasionally cause the fall of a horse and rider. When in pursuit of a gopher, a badger may dig into and endanger ditch banks, but in most cases the gopher, if left alone, [illegible]. Practically the only enemy of the badger [illegible] prehensible that men [illegible] every possible occasion [illegible] native mammals. [illegible] after a valley has been [illegible] scarce, and are [illegible] One of the [illegible] mice, and gophers [illegible] prise the farmer [illegible]

WEASELS.

Weasels are among the most beneficial of carnivorous mammals, as they are too small to do serious harm, and they prey almost exclusively on harmful rodents. A single weasel will effectually keep down the gophers and meadow mice on a field or small ranch. They are never numerous and therefore should be protected with the greatest care.

ARIZONA WEASEL.

(*Putorius arizonensis.*)

This is a rather small weasel, measuring in total length about 9 to 10 inches. In summer it is light-brown above and yellow below, but in winter it usually becomes whitish, or pure white, with only the tip of the tail black.

While never very common, these weasels are occasionally found along streams and ditches or in fields where they actively search for mice and other small rodents. Their scarcity is partly compensated for by their voracity and energy, and they kill every small animal that comes within their reach. They kill far more than they can eat, and seem tireless in pursuit of prey. Their slender form admits them readily to small burrows, where they quickly capture the occupants. They are the most effective enemy of pocket gophers, as they enter the burrows and quickly dispatch the occupants. In a narrow valley where an old weasel had her young I found it impossible to secure a single pocket gopher. Recently made mounds were numerous, but the gophers had been completely exterminated. Occasionally a weasel enters the henhouse and kills chickens, but a few chickens can well be spared in view of the immense benefit the little animals are constantly affording to agriculture. Except in very rare cases they should be protected in every way possible.

MINK.

Mink are rare in the arid regions and mainly restricted to water courses. A few are reported along the Humboldt and Truckee rivers, and they doubtless follow many other streams down into the valleys. They are so rare, however, as to be of little importance either as possible enemies to poultry or as valuable fur-bearing animals. In higher valleys of the mountains they are common.

OTTER.

There are a few otter along the Truckee River, in Pyramid Lake, and along the Humboldt and its branches. They are local or extremely scarce over most of the arid region, however, as the valley streams are few and usually not well supplied with fish.

BATS.

Bats are common almost everywhere within reach of water. Several species inhabit the Carson Sink and Humboldt valleys, some as rare or occasional visitors, others as abundant summer residents. Owing to the nocturnal flight of bats their habits are not well understood, but it is safe to say that all the Nevada species are not only harmless but highly beneficial. They feed entirely on insects caught on the wing. Bats shot in the evening after they have been flying for twenty minutes will usually be found so gorged that it does not seem possible that their stomachs can hold more. If their digestion is as rapid as that of other insectivorous mammals, the number of insects consumed in a night by a single bat must be enormous. The great deposits of bat guano found in caves and under roosting places represent in some cases hundreds of tons of insect remains.

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Issued September 26, 1908.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 336.

GAME LAWS FOR 1908.

A SUMMARY OF THE PROVISIONS RELATING TO SEASONS, SHIPMENT, SALE, LIMITS, AND LICENSES.

BY

T. S. PALMER AND HENRY OLDYS,
Assistants, Biological Survey.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1908.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Biological Survey,
Washington, D. C., August 25, 1908.

Sir: I have the honor to transmit herewith, for publication in the series of Farmers' Bulletins, a summary of the game laws for 1908 relating to seasons, shipment, sale, limits, and licenses, prepared by T. S. Palmer and Henry Oldys, of the Biological Survey. This bulletin is similar in scope to those issued annually since 1902 and includes changes in the laws made during the present year. The information here given is more condensed than that in previous bulletins, owing to the omission of the county laws of Maryland and North Carolina and the rearrangement of the matter relating to limits placed on the capture of game. The section relating to legislation includes references to most of the new laws and a summary of the more important bills which failed to pass—features believed to be of special value to those interested in game protection.

Respectfully,

C. Hart Merriam,
Chief, Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

GAME LAWS FOR 1908.

INTRODUCTION.

SCOPE OF THE BULLETIN.

The object of the present bulletin is to present in convenient form a summary of the game laws of the United States and Canada which govern seasons, shipment, sale, licenses, and limitations on amount that may be killed. Its purpose is, primarily, to furnish information concerning restrictions on trade in game, knowledge of which is necessary in the enforcement of the Federal statute regulating interstate commerce in game, commonly known as the Lacey Act. Hence such provisions as relate to methods of capture of game, enforcement of laws, disposition of fines and fees, and such matters as are of special or local application are not included. These may be found elsewhere, either in summaries prepared for the use of sportsmen by game associations, railroad companies, and private publishers, or from the laws themselves, which in most cases may be had in separate form from State game officials[a] or secretaries of state.

The demand for a publication containing a concise summary of existing game laws, both Federal and State, apparently increases in direct proportion with interest in game protection, and the need of such a summary constantly grows with the increasing complexity of game legislation and the prevalence in some States of county laws. In Maryland and North Carolina the legislatures enact separate laws for the different counties;[b] in New Jersey, Oregon, and Washington laws for different districts or sections of the State are fairly numerous and are becoming more so. In Louisiana the close season for deer must be fixed by the police jury of each parish, and in Nevada and Virginia county officers are empowered to shorten or shift open seasons. In the following tables such local laws and regulations are included as fully as possible, but as some are inaccessible and others are likely to be changed at any time an absolutely complete and accurate summary of them is impracticable.

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[a] A directory of these officers with their addresses and a list of the commissions which issue fish and game laws in separate form may be found in Circular No. 65 of the Biological Survey, U. S. Department of Agriculture, 1908.

[b] These laws are not included in this bulletin, but are given in Poster No. 18, which may be had upon application to the Biological Survey, U. S. Department of Agriculture.

LEGISLATION OF 1908.

The year 1908 was remarkable for the small amount of game legislation enacted. Regular legislative sessions were held in thirteen States[a]—Massachusetts, Rhode Island, New York, New Jersey, Maryland, Virginia, South Carolina, Georgia, Mississippi, Louisiana, Kentucky, Ohio, and Oklahoma. Game bills were under consideration in all of these States, and also in North Carolina, where a special ten-day session was held, but Kentucky, Mississippi, and Oklahoma made no changes in their game laws. The Georgia legislature met in June, so that the fate of bills is uncertain at the time of preparing this review. Omitting these four States and including Alaska, for which a new law was passed by Congress, the number of States which have made changes in their game laws this year is only ten, all except Louisiana east of the Mississippi River. In Canada at least six, or two-thirds, of the Provinces, amended their game acts. Including Canadian bills and an amendment passed by Newfoundland, the total number of new laws was less than 60, and about half of these were local measures.

New codes were adopted by New York, Ohio, and Nova Scotia, in which important modifications of existing law were incorporated. Protection of nongame birds was practically unchanged by these legislative enactments, as well as all others, with the exception of an amendment passed by Virginia removing all protection from doves, eagles, and beneficial hawks and owls. Protection was likewise removed from wild geese in Alberta.

Among the novel features of the year's legislation were the act of Congress providing hunting and shipping licenses for Alaska—the first measure of the kind ever passed by the Federal Government; the Quebec provision making lumbermen responsible for infractions of the game laws by their employees, and the Massachusetts requirement that the carcasses of deer killed in the protection of crops must be delivered to the city or town clerk on the day of killing.

There is a growing practice in the Provinces of Canada to delegate to the lieutenant-governor in council authority to make or alter certain provisions concerning game. Thus in British Columbia this officer was authorized during the present year to set aside tracts of Crown lands for game reserves and make necessary regulations therefor, and in Quebec to fix fees from time to time for the incorporation of fish and game organizations. Such powers, which are becoming somewhat numerous, while insuring greater flexibility in the laws, make it more difficult to keep abreast of existing provisions.

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[a] The legislature of Vermont does not meet until October.

Close seasons.—The most important changes in close seasons were the prohibition of spring shooting of waterfowl in northern New Jersey and shore birds in Rhode Island, and the abolition of summer woodcock shooting in New Jersey. Next in importance were the acts of New York, Virginia, and Newfoundland abolishing local seasons for rabbits and substituting therefor a single season throughout the State. New York took similar action with all its upland game.

The tendency toward more stringent protection appears in the addition of several species of plover in Virginia and capercailzie and black game in Newfoundland to the list of protected game, and in the shortening of seasons for various kinds of game in Massachusetts, New Jersey, Louisiana, and Manitoba, and for all game birds in Newfoundland, which now has a uniform season for all its small game. In several States the close seasons maintained for a period of years for certain kinds of game expired this year, but most of the close terms for big game, grouse, and pheasants were extended.

Sale and shipment.—In the legislation of the year a marked tendency is noticeable to increase restrictions on the marketing of game, especially in Louisiana, Ohio, Virginia, and Newfoundland, which place further limitations on the sale of game, Ohio for the first time cutting off sale of all game and Virginia of all upland game birds. The privilege of carrying out a limited amount of game is granted to nonresident licensees by New Jersey and New York, and Nova Scotia permits nonresidents to carry out one unmounted moose head under each hunting license. British Columbia makes an exception to its nonexport laws in favor of export of big game for scientific, zoological, or government purposes.

Bag limits.—In the new game acts of New York, Ohio, and Nova Scotia the bag limits are noticeably altered. New York reduces the day's bag of quail, grouse, and woodcock, and Ohio that of practically all game birds except ducks. Nova Scotia, on the other hand, permits a larger number of woodcock to be bagged per day than previously.

Licenses.—The growing popularity of the license system as a means of raising revenue and regulating hunting is evidenced by the large amount of attention it received from lawmakers. Resident hunting licenses were established for the first time in Louisiana, Massachusetts, New York, and Nova Scotia, and alien licenses in Alaska, New Jersey, and New York. A nonresident license was provided for Alaska, and those of Louisiana, New York, and British Columbia were increased. In the case of British Columbia the fee for the general license was doubled. South Carolina established a county license in additior its State license. In Alaska provision was also made for licens guides and for the issue of shipping licenses for big game. Alterat or loan of a hunting license is made a forgery by the New York law

Warden service.—Important changes tending to improve the war service were made in Louisiana and Nova Scotia. In Louisian board of three commissioners was established with headquarters New Orleans, and in Nova Scotia a similar board, also composed three members. In both cases these boards appoint the wardens supervise the enforcement of the game laws, duties which in N Scotia were previously intrusted to the Game and Inland Fish Protection Society. The new Alaska game law provided for the pointment of wardens by the governor, and that of Ohio authori the commissioners of fish and game to fix the salary of the cl warden, formerly limited to $1,500 per annum. Virginia extended duties of its game wardens to cover the protection of fish.

Preserves.—Few measures were adopted looking to the establ ment of game preserves, but an important item was incorporatec the agricultural appropriation bill setting aside $30,000 for the p chase of not more than 12,800 acres of land on the Flathead Ind Reservation in Montana for a national bison range, and $10,00 cover the cost of fencing. Important also was the action of Bri Columbia, already mentioned, authorizing the lieutenant-governo council to establish game preserves on Crown lands.

NEW LAWS PASSED IN 1908.

Alaska.—One act: Amending the law by establishing two game districts, north and one south of latitude 62°, with special seasons for each; establis a nonresident hunting license with fees of $50 for citizens of the United St and $100 for aliens, and resident and nonresident shipping licenses, ranging f $5 to $150; authorizing the governor to issue licenses, appoint wardens, es lish regulations for the registration of guides, and fix the rates for licen guides and the rates of compensation for guiding. (Stat. 60th Cong., 102.)

Georgia.—[Laws not received at the date of the publication of this bullet

Kentucky.—No legislation.

Louisiana.—Two acts: Changing the seasons for game birds and prohibi sale after March 1 and during close season of any game birds, native or ported, increasing the nonresident license to $25, providing for its issue by tax collector, and making it good only in the parish in which issued, and es lishing a $1 resident license required of persons hunting on land other than t own (No. 277); establishing a board of fish and game commissioners consis of three members, from the eastern, central, and western parts of the St respectively, authorized to arrest offenders without warrant, appoint ward and to maintain an office in New Orleans (No. 278).

Maryland.—No general legislation. Nineteen local laws: Modifying c seasons in Allegany, Carroll, Cecil, Kent, Queen Anne, Washington, Wicom and Worcester counties and on the Patuxent River; prohibiting export of game from Garrett and Worcester counties; establishing a $50 club license for shooting on the Patuxent River; reducing the nonresident license in Somerset County; altering license requirements in Queen Anne and Washington counties; authorizing arrest without warrant by wardens in Baltimore County and by landowners in Washington County; and making a few other changes.

Massachusetts.—Eight acts: Protecting gray squirrels until 1910 (ch. 284); providing for an equal disposition of the fines under the game laws between the county and the Commonwealth, unless the plaintiff be a paid deputy of the commission, in which case the Commonwealth receives all fines (ch. 330); prohibiting the use of boats in the pursuit of wild fowl in certain waters of Edgartown (ch. 331); extending the close season for deer to 1910, and requiring farmers killing them in protecting their crops to deliver each carcass on the day on which it was killed to the clerk of the city or town (ch. 377); authorizing the sale at any time of hares or rabbits not taken contrary to law in Massachusetts or elsewhere (ch. 413); making a uniform open season of one month for ruffed grouse, woodcock, and quail (ch. 441); abolishing the open season for male pheasants (ch. 477); and requiring residents of the State to obtain hunting licenses at $1 each from the city and town clerks after January 1, 1909 (ch. 484).

Mississippi.—No legislation.

New Jersey.—Seven acts: Licensing unnaturalized foreign-born resident hunters (ch. 76); prohibiting spring shooting of wild fowl in the northern counties and shortening the season in the southern section of the State (ch. 94); permitting importation of game from other States when such game can be lawfully shipped from said States (ch. 202); prohibiting trespassing on occupied lands, for purposes of hunting or fishing, without the consent of the owner or tenant (ch. 204); modifying open seasons for upland game in the northern and southern sections of the State (ch. 222); reenacting the law licensing nonresident hunters and authorizing them to export a limited amount of upland game (ch. 243); extending laws to cover imported game and providing for cold storage of such game under bond in close seasons (ch. 281).

New York.—One act: Codifying the entire game, fish, and forestry law, simplifying the deer, squirrel, rabbit, quail, and woodcock seasons, giving shore birds a month's additional protection on Long Island, prohibiting wild-fowl hunting before sunrise or after sunset, protecting wood duck throughout the year, providing for the proper marking of packages of game when shipped, increasing the nonresident license to $20, requiring aliens to secure a nonresident license before hunting, and providing a $1 license for residents, making the alteration or loan of licenses a forgery, reducing the bag limit on quail, grouse, and woodcock, prohibiting the sale of quail taken in the State, and permitting the export of 1 deer under the nonresident license (ch. 130).

North Carolina.—Seven acts: Changing the seasons for deer in Richmond (chs. 1 and 2), Hertford (ch. 22), and Jackson counties (ch. 65); repealing the special nonresident license law in Randolph County (ch. 27); permitting the killing of loons in April in Carteret County (ch. 86); and shortening the open season for quail in Greene County two months until 1911.

Ohio.—Two acts: Extending the close season for ruffed grouse and pheasants to 1913 (H. B. 804); and an act codifying the game and fish laws in which the open season for plover, snipe, rail, and waterfowl is extended to January 1, the seasons for squirrels and raccoons are shortened, the bag limit on squirrels is removed and the bag limit on upland game birds, shore birds, and geese is reduced from 18 to 12 a day, the reading of the nongame bird law in schools is dispensed with, and the limited nonsale provisions of the [illegible] replaced with an unqualified prohibition of all sale of game, both domestic and imported (S. B. 521).

Oklahoma.—No legislation.

Rhode Island.—Two acts: Prohibiting the use of wire snares (ch. 1567); and providing a close season for shore birds, previously unprotected, and prohibiting shooting them in spring (ch. 1582).

South Carolina.—Four acts: Repealing the special season for upland game birds in Lexington County (No. 457): amending the law protecting partridges or quail by prohibiting sale of native quail until 1912, extending the protection of Mongolian pheasants to 1912, and requiring nonresidents to pay $25 for licenses to hunt wild turkeys, partridges, or quail within any county of the State, but exempting landowners and special guests of residents (No. 499): amending the provisions of the section in the Audubon law relating to the oath and bond of game wardens (No. 531); and fixing a special season for hunting upland game birds in Kershaw County (No. 536).

Virginia.—Four acts: Making game wardens fish wardens (ch. 33); prohibiting sale or shipment of quail or ruffed grouse captured in Carroll, Grayson, or Patrick counties (ch. 89); amending sections 2070a and 2079 of the code by making the deer season one month earlier, abolishing the local rabbit seasons and providing a uniform season for the entire State, but permitting residents to kill rabbits on their own lands at any time, shortening the robin seasons from eleven to six and one-half weeks, extending the waterfowl season one month, fixing a close season for three kinds of plover previously unprotected, prohibiting the sale at any time of upland game birds, and removing protection from all doves, hawks, owls, and eagles (ch. 176); and modifying the law governing shooting of wild fowl on Back Bay, Princess Anne County, so as to permit the shooting of wild geese at night in March, and shortening the open season for coots ("blue peters") from eleven months to two (ch. 230).

Alberta.—One act: Removing all protection from wild geese (ch. 20, sec. 30).

British Columbia.—One act: Amending the game law by authorizing the provincial secretary to issue permits for the export of animals or birds for scientific, zoological, or government purposes, increasing the nonresident license fee to $100, and authorizing the lieutenant-governor in council to set aside tracts of Crown lands for game reserves and to make regulations for the protection of game and carrying of firearms within such reserves (ch. 18).

Manitoba.—One act: Shortening the open season for grouse, partridges, and prairie chickens by fifteen days (ch. 19).

Newfoundland.—One act: Providing a close season for hares and rabbits, protecting capercailzie and black game to 1917 and prohibiting their sale, and shortening the season for other game birds one month, making it uniform with the rabbit season.

Nova Scotia.—One act: Consolidating previous game acts, extending the close season for deer and caribou to 1912, providing for the appointment of a board of game commissioners consisting of a chief commissioner and two assistant commissioners for enforcing the game laws—duties formerly exercised by the Nova Scotia Game and Inland Fishery Protection Society—providing a $5 license for residents to shoot woodcock and snipe outside county of residence, increasing the bag limit on woodcock from 10 to 15 per day, removing former restrictions on export of moose killed by nonresident licensees, giving wardens authority to arrest without warrant, and making minor changes (ch. 17).

Quebec.—Two acts: Prohibiting the sale of birch or swamp partridges until October 1, 1910, holding heads of lumbering establishments and contractors and subcontractors engaged in lumbering operations responsible for all offenses against the game laws respecting deer, moose, and caribou committed by men under their control, and making minor changes (ch. 25); and amending the revised statutes respecting the incorporation of fish and game protective clubs by allowing the lieutenant-governor in council to fix the fee therefor from time to time (ch. 70).

BILLS WHICH FAILED TO PASS.

Bills were introduced in Congress authorizing the establishment of the Glacier National Park in Montana (S. 5648) and game refuges in the national forests in California (H. R. 10449), but were still pending at the time of adjournment.

In Kentucky at least eight bills were introduced, but all failed of passage. These included a bill to protect birds and squirrels near city parks (H. B. 60), and a comprehensive measure to establish a game and fish commission of five members, provide bag limits, resident and nonresident licenses, and an appropriation of $10,000 to enforce the provisions of the act (S. 104). A unique feature of the latter bill was a $1 resident license for hunting with ordinary guns and a $2 license for hunting with guns carrying more than two cartridges.

In Massachusetts about twenty-five bills for the protection of game were introduced, but less than one-third became laws. Several of these measures were devoted to the protection of deer, squirrels, and upland game birds. Among the bills which failed was one prohibiting spring shooting of wild fowl and shore birds, which was referred to the next legislature. Unsuccessful attempts were also made to provide an open season for deer during the last ten days in November (H. 322); prohibit further propagation of pheasants by the State (H. 503); make a uniform season for all game from October 15 to November 15[*] (H. 513); prohibit payment of any part of fines to deputy wardens or other officers (H. 811): and limit the number of woodcock, grouse, and quail which can be killed by any person to 5 of one kind or 10 in all per day, or 40 in a season (H. 812). Several bills designed to further protect ruffed grouse and other upland game failed of passage.

Among the bills which failed to pass in New Jersey were those prohibiting the sale of upland game birds (A. 90); prohibiting the sale of all game birds and fixing bag limits (S. 160); prohibiting spring shooting of waterfowl and shore birds and protecting wood ducks until 1915 (S. 172); and prohibiting shooting of waterfowl between January 1 and October 1 (A. 215).

In New York there were bills to restrict the section relating to bonding fish and game to fish only (A. 322): to permit spring shooting on

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[*] The principle of a uniform open season for all game was adopted by Michigan in 1869 and by Montana in 1905; Michigan made the open season September 1 to January 1, and Montana September 1 to December 1.

Long Island by extending the open season to March 1 instead of January 1 (A. 663); to permit the sale of wild fowl during the first ten days of January (S. 450); to prevent possession of wild fowl 60 days after the commencement of the close season, to prohibit killing of brant from January 1 to May 1, to secure protection for beneficial hawks, the snowy owl, and the crow blackbird, and to modify the section relating to sale of plumage.

In Ohio among the measures that received unfavorable consideration were bills to establish resident and alien licenses, reduce the nonresident license to $10, and the export limit to 25 birds; to give greater protection to quail and wild turkeys, extend the rabbit season, and encourage the propagation of imported pheasants.

The bills under consideration in Oklahoma included the so-called "model law" for the protection of nongame birds, a game warden bill, several bills protecting game, and a comprehensive measure including, among other features, a system of resident and nonresident licenses. The failure of all game legislation was somewhat unexpected and had the effect of preventing the warden department from being made self-sustaining through income received from hunting licenses.

In Rhode Island bills to establish a close season of one year for upland game, provide a resident license, prohibit spring shooting of wild fowl, and repeal the bounty on hawks, owls, and crows, were considered but failed to become laws.

One of the most important bills introduced in Virginia provided for a State officer charged with enforcement of the game laws. Similar measures were introduced at one or two previous sessions but thus far all attempts to establish a comprehensive warden service in this State have been unsuccessful.

CLOSE SEASONS.

All the general close seasons for game prescribed by the various States and by the Provinces of Canada are here brought together in one table. For the sake of simplicity a uniform method is used in both the arrangement of species and statement of seasons. In each case deer and other big game are first considered; then squirrels and rabbits; then upland game birds, such as quail, grouse, pheasants, turkeys, and doves; then shore birds; and finally waterfowl, such as ducks, geese, and swans. In the statement of seasons only close seasons have been given, and in stating these the plan of the Vermont law, to include the first date but not the last, has been followed consistently.[a] The Vermont scheme has the advantage of showing readily both the open and close seasons, since either may be obtained by reversing the dates of the other.

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[a] See discussion of this question in Circular No. 43 of the Biological Surey, U. S. Department of Agriculture, 1904, entitled "Definitions of the open and close seasons for game."

In some States certain days of the week constitute additional close seasons throughout the term in which killing is permitted. Hunting on Sunday is prohibited in all except four of the States east of the Mississippi, and in Iowa, Kansas, Missouri, Minnesota, Nebraska, North Dakota, and Oklahoma, as well as in most of the Canadian Provinces. Mondays constitute a close season for waterfowl in Ohio, and other week days for wild fowl in several favorite ducking grounds in Delaware, Maryland, Virginia, and North Carolina. Hunting is prohibited on election day in Baltimore, Cecil, Frederick, and Harford counties, Maryland. The county laws of Maryland and North Carolina, which are too numerous to be included satisfactorily, are given in detail in Poster No. 18, "Close seasons for game in Maryland, District of Columbia, Virginia, and North Carolina, 1908,"[a] but are not incorporated in the following table, which otherwise may be regarded as a practically complete résumé of the regulations now in force. The difficulty of securing absolute accuracy in a table of this kind is very great, and the absence in the laws of many States of express legislation as to the inclusion or exclusion of the date upon which seasons open and close makes exactness almost an impossibility.

CLOSE SEASONS FOR GAME IN THE UNITED STATES AND CANADA, 1908.

[The close seasons include the first date, but not the last. To find the open seasons *reverse the dates.* Seasons which apply only to special counties are placed to the left of the column containing the close seasons for the State in general.]

	Close seasons.
Alabama (1907):	
Male deer (does protected all the year)	Jan 1–Nov. 1.
Squirrel (black, gray, or fox)	Jan. 1–Aug. 1.[b]
Quail or partridge	Mar. 1–Nov. 1.
Wild turkey gobblers (hens protected all the year)	Apr. 1–Dec. 1.
Ruffed grouse (pheasant), imported pheasant or other introduced game birds	Until Dec. 1, 1912.
Dove	Mar. 1–Aug. 1.
Snipe, plover	May 1–Nov. 1.
Rail, coot, mud hen, woodcock, sandpiper, curlew, other shore birds, duck, goose, brant, swan	Mar. 15–Sept. 1.
Alaska[c] (1908):	
North of latitude 62°:	
Moose, caribou, sheep	Dec. 11–Aug. 1.
South of latitude 62°:	
Deer, mountain goat	Feb. 2–Apr. 1.
Moose, caribou (see exception), sheep	Jan. 1–Aug. 20.
Exception: Caribou on the Kenai Peninsula. To Aug. 20, 1912	
Brown bear	July 2–Oct. 1.
Grouse, ptarmigan, shore birds, waterfowl	Mar. 2–Sept. 1.

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[a] This poster may be had upon application to the Biological Survey, U. S. Department of Agriculture, Washington, D. C.

[b] Except May 15–June 15.

[c] Game animals or birds may be killed at any time for food or clothing by native Indians or Eskimo, or by miners or explorers in need of food, but game so killed can not be shipped or sold.

	Close season
Arizona (1905):	
Male deer	Dec. 1–Sept. 15.
Female deer, spotted fawn, elk, sheep, goat	All the year.
Antelope, 6 years	Until Mar. 1, 19
Quail, bobwhite, partridge, grouse, pheasant, snipe, rail	Mar. 1–Oct. 15.
Introduced pheasant (Chinese, Japanese green, golden, ringneck) 6 years	Until Mar. 1, 19
Wild turkey	Dec. 1–Sept. 15.
Arkansas (1901–1907):	
Deer	Feb. 1–Sept. 1.
Squirrel in Lee, Monroe, Phillips, and St. Francis counties	Dec. 1–May 1.
Quail or partridge	Mar. 1–Nov. 1.
Pinnated grouse, prairie chicken	Dec. 1–Oct. 31.
Pheasants (Chinese, English), 10 years	Until Mar. 14, 1
Wild turkey	May 1–Sept. 1.
Dove	All the year.
California [a] (1901–1907):	
Male deer	Oct. 1–July 15.
Tree squirrel	Jan. 1–Sept. 1.
Female deer, fawn, elk, antelope, sheep	All the year.
Valley quail, partridge, plover, curlew, ibis, rail, shore birds	Feb. 15–Oct. 15.
Mountain quail	Feb. 15–Sept. 1.
Grouse, sage hen	To Sept. 1, 1909
Pheasants, bobwhite, imported quail or partridge, swan	All the year.
Dove	Oct. 15–July 15.
Wilson snipe	Apr. 1–Oct. 15.
Duck	Feb. 15–Oct. 1.
Colorado (1899–1907):	
Deer	Oct. 21–Oct. 1.
Elk, 4 years	Until Nov. 1, 19
Antelope with horns, sheep with horns, 4 years	Until Oct. 15, 19
Antelope and sheep without horns	All the year.
Quail (bobwhite, crested), 13 years	Until 1920.
Wild turkey, pheasant, partridge, ptarmigan, wild pigeon, crane	All the year.
Grouse, prairie chicken	Oct. 2–Aug. 20.
Sage chicken	Oct. 2–Aug. 1.
Dove	Sept. 6–Aug. 15.
Plover, curlew	Oct. 31–Aug. 1.
Snipe, shore birds, duck, goose, brant, swan, waterfowl (see exception)	Apr. 16–Sept. 1
Exception: Altitudes above 7,000 feet	May 2–Sept. 15
Connecticut (1901–1907):	
Deer, 10 years	Until June 1, 19
Gray squirrel, hare, rabbit	Dec. 1–Oct. 1.
Quail, ruffed grouse, woodcock, pheasant (Chinese, Mongolian)	Dec. 1–Oct. 1.
Dove	All the year.
Plover, Wilson or English snipe, bay snipe, sandpipers, shore birds, gallinule, mud hen, duck, goose, brant, swan	Jan. 1–Sept. 1.
Rail	Jan. 1–Sept. 12.
Delaware (1893–1905):	
Squirrel (other than red, and only in Kent and Newcastle counties), rabbit	Jan. 1–Nov. 15.
Quail, partridge, pheasant	Jan. 1–Nov. 15.
Dove	All the year.
Reedbird, ortolan or rail	Feb. 2–Sept. 1.
Duck (except wood duck), goose, brant, swan	Apr. 16–Oct. 1
District of Columbia [c] (1899–1906):	
Deer meat (sale or possession)	Jan. 1–Sept. 1.
Squirrel, rabbit (except English rabbit, Belgian hare)	Feb. 1–Nov. 1.

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[a] Seasons fixed by ordinances of boards of county supervisors are omitted.

[b] Wild fowl on Assawaman Bay and tributaries, Sussex County, May 1–Nov. 1, a
Mondays, Thursdays, Saturdays, and Sundays in the open season.

[c] Hunting prohibited in the District, by act of June 30, 1906, except on the mars
the Eastern Branch above the Anacostia Bridge, and on the Virginia shore of the Po
provided no birds are shot within 200 yards of any bridge or dwelling.

District of Columbia (1899–1906)—Continued.	*Close seasons.*
Quail or partridge	Mar. 15–Nov. 1.
Ruffed grouse or pheasant (except English, ringneck, or other imported pheasants raised in inclosures, sale or possession unrestricted), wild turkey	Dec. 20–Nov. 1.
Prairie chicken or pinnated grouse	Mar. 15–Sept. 1.
Dove	All the year.
Woodcock	Jan. 1–July 1.
Snipe, plover, duck, goose, brant	Apr. 1–Sept. 1.
Reedbird, marsh blackbird, rail or ortolan, other game birds not previously mentioned	Feb. 1–Sept. 1.
Florida[a] (1903):	
Deer	Feb. 1–Nov. 1.
Quail or partridge, wild turkey	Mar. 1–Nov. 1.
Duck	Apr. 1–Oct. 1.
Georgia (1903–1905):	
Deer	Jan. 1–Sept. 1.
Quail, partridge, pheasant, wild turkey	Mar. 15–Nov. 1.
Dove, snipe, marsh hen	Mar. 15–Sept. 1.
Woodcock, wood duck or summer duck	Feb. 1–Sept. 1.
Hawaii (1905):	
Quail, pheasant	Mar. 1–Sept. 16.
Wild dove, wild pigeon	Feb. 1–July 1.
Imported birds	All the year.
Snipe, plover, turnstone, curlew, stilt, mud hen, migratory duck	May 1–Sept. 16.
Native wild duck, Hawaiian goose	Feb. 1–Sept. 16.
Idaho (1907):	
Deer, elk, sheep, goat	Jan. 1–Sept. 15.
Moose, caribou, antelope, buffalo	All the year.
Quail	Dec. 1–Nov. 1.
Grouse	Dec. 1–Aug. 15.
Partridge, pheasant, turtle dove, prairie chicken	Dec. 1–Sept. 1.
Sage hen	Dec. 1–Aug. 1.
Mongolian pheasant, Canada grouse or fool hen, swan, 4 years	Until Mar. 14, 1911.
Snipe, plover, duck, goose	Jan. 1–Sept. 15.
Illinois (1903–1907):	
Deer,[b] 10 years	Until May 28, 1917.
Squirrel (gray, red, fox, or black)	Nov. 16–July 1.
Quail	Dec. 20–Nov. 11.
Ruffed grouse, prairie chicken, Mexican blue quail, California mountain quail, California valley quail, Hungarian partridge, capercailzie, black grouse, 4 years	Until July 1, 1911.
Wild turkey, pheasants (copper or Soemmering, English, golden, green Japanese, Mongolian, ringneck, silver, tragopan, Reeves, Elliot, Hungarian, Swinhoe, Amherst, melanotte, impeyan, argus), partridge (black Indian, caccabis, chukar), sand grouse, 6 years	Until July 1, 1913.
Mourning dove, woodcock	Dec. 1–Aug. 1.
Jacksnipe or Wilson snipe, sand or other snipe, golden, upland, or other plover	May 2–Sept. 1.
Duck, goose, brant, or other waterfowl	Apr. 16–Sept. 1.
Indiana (1905–1907):	
Deer[c]	All the year.
Squirrel	Nov. 1–July 1.[d]
Woodcock	Jan. 1–July 1.[d]
Quail, ruffed grouse, prairie chicken, or pinnated grouse	Jan. 1–Nov. 10.
Pheasants, wild turkey, dove	All the year.

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[a] It is unlawful to kill game or game birds within 1 mile of West Palm Beach; similar regulations are in force at St. Augustine. Special seasons: Clay County, quail, wild turkey, Mar. 1–Nov. 1 and all but 2 days each week rest of year; Hernando County, deer, quail, Feb. 1–Dec. 1, wild turkey, Apr. 1–Mar. 1, dove, duck, Mar. 1–Dec. 1.

[b] Deer raised in inclosure for market may be killed at any time.

[c] Deer raised in private preserves may be killed at any time.

[d] Unlawful to hunt any game except waterfowl Oct. 1–Nov. 10.

Indiana (1905–1907)—Continued.	*Close season*
Duck, goose, brant, or other waterfowl	Apr. 1–Sept. 1.
Iowa (1897–1907):	
Deer, elk	All the year.
Squirrel (gray, timber, or fox)	Jan. 1–Sept. 1.
Quail, ruffed grouse or pheasant, wild turkey	Dec. 15–Nov. 1.
Pinnated grouse or prairie chicken	Dec. 1–Sept. 1.
Pheasants (English, Mongolian, Chinese, ringneck)	Until Oct. 1, 19
Turtle dove	All the year.
Woodcock	Jan. 1–July 10.
Sandpiper, plover, rail, marsh or beach birds, duck, goose, brant	Apr. 15–Sept. 1.
Kansas (1903–1907):	
Red squirrel	All the year.
Quail	Dec. 15–Nov. 1
Grouse, prairie chicken (see exception)	Oct. 15–Sept. 1
Exception: Prairie chicken in Butler County, 3 years, To Mar. 9, 1910	
Pheasants (English, Mongolian, or Chinese), Hungarian partridge, 6 years	Until Feb. 27, 1
Dove	Sept. 15–Aug. 1
Plover	Sept. 15–July 1
Duck, goose, brant	Apr. 15–Sept. 1.
Kentucky (1894–1906):	
Deer	Mar. 1–Sept. 1.
Rabbit (except with dogs or snares)	Sept. 15–Nov. 1
Squirrel (black, gray, or fox)	Feb. 1–Nov. 15.[a]
Quail, partridge, pheasant	Jan. 1–Nov. 15.
Pheasants (English, ringneck, Mongolian, or Chinese)	All the year
Wild turkey	Feb. 1–Sept. 1.
Dove	Feb. 1–Aug. 1.
Woodcock	Feb. 1–June 20.
Wood duck, teal, or other duck, goose	Apr. 1–Aug. 15.
Louisiana (1904–1908):	
Deer (female and young protected all the year)	Local seasons.[b]
Quail, wood duck	Mar. 1–Nov. 1.
Prairie chicken, woodcock, 2 years	Until Dec. 1, 191
Male wild turkey (female protected all the year)	Apr. 15–Nov. 1.
Snipe, sandpiper (chorook and papabotte)	May 15–Sept. 1.
Dove	Mar. 1–Sept. 1.
Plover, tatler, curlew, rail (mud hen), gallinule, coot (poule d'eau), duck (except wood duck and blue-wing teal), goose, brant	Mar. 1–Oct. 1.
Blue-wing teal	Apr. 15–Oct. 1.
Maine (1903–1907):	
Deer (see exceptions)	Dec. 16–Oct. 1.
Exceptions: Androscoggin County — Nov. 1–Oct. 1	
Counties of Cumberland (females to 1909), Kennebec, Knox, Lincoln, Sagadahoc (except towns of Bath, West Bath, and Phippsburg, all the year), York (females all the year), and Waldo — Dec. 1–Nov. 1	
Hancock County—In towns of Eden, Mount Desert, Southwest Harbor, and Tremont, Dec. 15–Nov. 15; Isle au Haut (on islands) until Feb. 13, 1913, and Swan Island until Dec. 15, 1908; otherwise as in State law.	
Bull moose	Dec. 1–Oct. 15.
Cow and calf moose	All the year.
Caribou, 6 years	Until Oct. 15, 1
Squirrel (gray and black)	Until May 1, 19
Rabbit (except Hancock County)	Apr. 1–Sept. 1.

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[a] Except June 15–Sept. 15.

[b] Close seasons for deer in Louisiana, not less than 7 months in length, to be by police juries of the several parishes, but north of latitude 31° the period from to Aug. 15 to be always included.

ine (1903–1907)—Continued.		*Close seasons.*
Quail, dove		All the year.
Ruffed grouse or partridge, woodcock		Dec. 1–Sept. 15.
Pheasant, black game, capercailzie, 10 years		Until Apr. 28, 1913.
Snipe, sandpiper, plover		May 1–Aug. 1.
Wood duck, dusky or black duck, teal, gadwall or gray duck, mallard, widgeon or baldpate, shoveler, pintail or sprigtail, redhead, scaup or greater bluebill, lesser scaup or lesser bluebill, golden-eye or whistle, bufflehead, ruddy duck or broadbill		Jan. 1–Sept. 1.
Exceptions: Golden-eye (Hancock Co.); ducks (Lincoln Co.)	Feb. 1–Sept. 1	
All ducks on the Kennebec River below Gardiner and in Merrymeeting Bay	Dec. 1–Sept. 1	
ryland[a] (1898–1908):		
Squirrel		Dec. 1–Sept. 1.
Rabbit		Dec. 25–Nov. 1.
Quail, ruffed grouse, wild turkey		Dec. 25–Nov. 1.
Pheasants (English, Mongolian)		Dec. 25–Nov. 1.
Dove		Dec. 25–Aug. 15.
Woodcock		Dec. 25–Nov. 1.[b]
Snipe, plover		May 1–Aug. 15.
Reedbird, sora (water rail or ortolan)		Nov. 1–Sept. 1.
Duck, goose, brant, swan, and other wild fowl		Apr. 10–Nov. 1.
ssachusetts (1902–1908):		
Deer, 2 years		Until Nov. 1, 1910.
Gray squirrel		Until Oct. 1, 1910.
Hare or rabbit		Mar. 1–Oct. 1.
Quail, ruffed grouse or partridge, woodcock		Nov. 1–Oct. 1.
Prairie chicken, dove, wild or passenger pigeon, pheasants (English, golden, Mongolian)		All the year.
Heath hen, wood or summer duck, 5 years		Until Sept. 1, 1911.
Bartramian sandpiper (upland plover)		Until July 15, 1910.
Snipe, sandpiper, plover (except upland plover), rail, or any "shore," "marsh," or "beach" birds		Mar. 1–July 15.
Black duck, teal		Mar. 1–Sept. 1.
Other ducks		May 20–Sept. 1.
chigan[c] (1905–1907):		
Deer (see exceptions)		Dec. 1–Nov. 10.
Exceptions: Deer in red coat and fawn in spotted coat		All the year.
Arenac, Bay, Benzie, Cheboygan, Emmet, and Leelanau counties	Until 1912	
Bois Blanc Island	Until 1918	
Kalkaska County	Until 1910	
Elk (see exception), moose, caribou, 8 years		Until June 16, 1913.
Exception: Elk on Bois Blanc Island	Until 1918	
Squirrel (black, fox, or gray)		Dec. 1–Oct. 15.
Quail (bobwhite), ruffed grouse (partridge), spruce hen (see exception)		Dec. 1–Oct. 15.
Exception: Upper Peninsula (ruffed grouse, spruce hen)	Dec. 1–Oct. 1	
Pinnated grouse (prairie chicken), wild turkey, capercailzie, black game, hazel grouse, pheasants (English, Mongolian), wild pigeon		Until 1910.
European partridge		Until 1912.
Dove		All the year.
Snipe, plover, woodcock, duck, goose, brant, or other waterfowl (except that snipe, bluebill, canvasback, widgeon, redhead, pintail, whistler, spoonbill, butterball, and sawbill duck, goose, and brant may be hunted Mar. 2–Apr. 26, and goose and brant in Chippewa County at any time)		Jan. 2–Sept. 1.

The seasons given are the most general. For all seasons under county laws, see Poster 18, "Close seasons for game, Maryland, District of Columbia, Virginia, and North olina, 1908," which may be had upon application to the Biological Survey, U. S. De- ment of Agriculture, Washington, D. C.

Except July.

On Grand Island, Alger County, native deer, mule deer, blacktail [illegible] bou, antelope, buffalo, native partridge, Manitoba grouse, [illegible] an), and ptarmigan are protected to June 7, 1910.

Minnesota (1905–1907):	*Close seasons.*
Deer, male moose	Dec. 1–Nov. 10.
Elk, female moose, caribou, fawn	All the year.
Quail, partridge, ruffed grouse (pheasant)	Dec. 1–Oct. 1.
Sharp-tailed or white-breasted grouse, pinnated grouse or prairie chicken, turtle dove, woodcock, snipe, upland plover, golden plover	Nov. 1–Sept. 1.
Pheasants (Chinese, English, Mongolian, golden, Reeves, Japanese, tragopan, Temminck)	Until Jan. 1, 1910.
Duck, goose, brant, or any aquatic fowl	Dec. 1–Sept. 1.
Mississippi (1906):	
Deer (spotted fawn all the year), bear	Mar. 1–Nov. 15.
Quail or partridge	Mar. 1–Nov. 1.
Wild turkey (females all the year)	May 1–Jan. 1.
Dove	Mar. 1–Aug. 1.
Plover, tatler, chorook, grosbec, coot (poule d'eau), rail (mud hen), duck, goose, brant, swan	Mar. 1–Sept. 1.
Missouri (1907):	
Deer	Jan. 1–Nov. 1.
Squirrels (gray, black, fox)	Jan. 1–June 1.
Quail (bobwhite, partridge)	Jan. 1–Nov. 1.
Ruffed grouse (pheasant), pinnated grouse (prairie chicken), Mongolian, Chinese, and English pheasants, and other imported game birds	Until 1910.
Wild turkey	Feb. 1–Dec. 1.
Dove, woodcock, plover	Jan. 1–Aug. 1.
Snipe, duck, goose	May 1–Sept. 15.
Montana (1905–1907):	
Deer	Dec. 15–Sept. 1.
Elk, antelope, sheep, goat	Dec. 1–Sept. 1.
Moose, caribou, bison or buffalo	All the year.
Quail, Chinese pheasant	All the year.
Pheasant, partridge, prairie chicken, sage hen, fool hen, grouse, turtle dove, duck, goose, brant, swan	Dec. 1–Sept. 1.
Nebraska (1901–1907):	
Deer, elk, antelope, squirrel (gray, red, fox, timber)	All the year.
Quail	Dec. 1–Nov. 15.
Partridge, pheasant, ptarmigan, English partridge, Belgian partridge, English pheasant, Chinese pheasant, English black cock, other imported game birds, wild turkey, curlew	All the year.
Prairie chicken, sage chicken, grouse, wild pigeon, dove, plover	Dec. 1–Sept. 15.
Snipe, yellowlegs, crane, duck, goose, brant, or any game waterfowl	Apr. 11–Sept. 15.
Nevada[a] (1901–1903):	
Deer, antelope (males)	Nov. 15–Sept. 15.
Female deer and antelope, spotted fawn; all elk, caribou, sheep, goat	All the year.
Quail, grouse, prairie chicken, woodcock, snipe, plover, curlew, sandhill crane, duck	Mar. 1–Sept. 15.
Sage hen	Feb. 16–July 15.
Dove	Nov. 2–July 15.
Swan	All the year.
New Hampshire (1901–1907):	
Deer in Carroll and Coos counties	Dec. 1–Oct. 1
Deer in Grafton County	Dec. 15–Nov. 1
Deer in rest of State	Dec. 15–Dec. 1
Elk, moose, caribou	All the year.
Gray squirrel	Until Oct. 1, 1913.
Hare, rabbit	Mar. 1–Oct. 1.
Quail, partridge, ruffed grouse, woodcock, Wilson snipe	Dec. 1–Oct. 1.
Dove	All the year.

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[a] County commissioners may change dates of close seasons (without altering length for deer, antelope, or sage hens, or lengthen close seasons for any other game in the respective counties.

ew Hampshire (1901–1907)—Continued.	*Close seasons.*
Killdeer, upland plover or Bartramian sandpiper, wood duck	Until Mar. 7, 1912.
Sandpiper, yellowlegs, plover, rail, duck (except sheldrake) ("beach birds," teal, coot, may be shot in Rockingham County July 15–Feb. 1)	Feb. 1–Oct. 1.
ew Jersey (1903–1908):	
Deer[a] 3 years	Until Nov. 10, 1909.
Squirrel, rabbit—northern section[b]	Dec. 2–Oct. 15.
Squirrel, rabbit—southern section	Jan. 1–Nov. 15.
Quail, ruffed grouse (partridge), prairie chicken, English (ringneck) pheasant,[c] wild turkey, woodcock—northern section[b]	Dec. 2–Oct. 15.
Quail, ruffed grouse (partridge), prairie chicken, English (ringneck) pheasant,[c] wild turkey, woodcock—southern section	Jan. 1–Nov. 15.
Dove	All the year.
English or Wilson snipe (bog or jack snipe)	Jan. 1–Sept. 1.[d]
Surf (bay) snipe, sandpiper, yellowlegs, plover (except upland plover), curlew, all shore birds	Jan. 1–May 1.
Upland plover	Oct. 1–Aug. 1.
Reedbird, rail, marsh hen	Jan. 1–Sept. 1.
Duck, goose, brant, swan, or other wildfowl—northern section[b]	Jan. 2–Oct. 15.
Duck, swan—southern section	Mar. 16–Nov. 1.
Goose, brant—southern section	Mar. 26–Nov. 1.
ew Mexico (1905–1907):	
Deer (with horns)	Dec. 1–Oct. 15.
Deer (without horns), elk, sheep	All the year.
Antelope, 5 years	Until Mar. 13, 1910.
Quail (native or crested)	Feb. 1–Oct. 1.[e]
Mountain grouse, prairie chicken, wild turkey	Jan. 1–Oct. 1.
Bobwhite quail, pheasants, wild pigeon, 5 years	Until Mar. 13, 1910.
Ptarmigan	All the year.
Turtle dove	May 1–July 15.
ew York (1908):	
Deer—Adirondack region[f] and Dutchess County	Nov. 1–Sept. 16.
Deer—rest of State (see exception)	All the year.
Exception: Towns of Cochecton, Tusten, Highland, Lumberland, Forestburg, and Bethel in Sullivan County, and the town of Deer Park in Orange County	Nov. 1–Oct. 16
Fawns, elk, moose, caribou, antelope	All the year.
Squirrel, black or gray (see exception)	Dec. 1–Oct. 1.
Exception: Richmond and Steuben counties	All the year.
Hare, rabbit (see exception)	Dec. 1–Oct. 1.
Exception: Clinton, Essex, Franklin, Fulton, Hamilton, Herkimer, Jefferson, Lewis, Saratoga, Saint Lawrence, Warren, and Washington counties	Jan. 3–Oct. 1
Quail (see exception)	Dec. 1–Nov. 1.
Exception: Dutchess County, 2 years	Until 1910

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[a] Not applicable to deer in game preserves or to possession of imported deer properly gged.

[b] The northern section comprises the counties of Bergen, Essex, Hudson, Hunterdon, orris, Passaic, Somerset, Sussex, Union, and Warren; the southern section comprises the maining counties of the State.

[c] English or ringneck pheasants in established game preserves may be shot Oct. 1–Jan. 1 the owners of such preserves or such persons as they may designate.

[d] Except March and April.

[e] County commissioners on petition of 25 resident householders in any precinct may tend the open season to April 1 in such precinct.

[f] The Adirondack region comprises the counties of Clinton, Essex, Franklin, Fulton, amilton, Herkimer, Saratoga, Saint Lawrence, Warren, and Washington, and that part Jefferson, Lewis, and Oneida counties lying east of the Utica and Black River R. R. om Utica to Ogdensburg.

York (1908)—Continued.	*Close seasons.*
Grouse (see exceptions)	Dec. 1–Oct. 1.
Exceptions: Steuben and Westchester counties	All the year
Pheasants (Mongolian, ringneck, English), 2 years (see exception)	Until 1910.
Exception: Dutchess County	Jan. 1–Nov. 1
Dove, wood duck	All the year.
Woodcock	Dec. 1–Oct. 1.
Plover, Wilson or English snipe, jacksnipe, bay snipe, yellowlegs, surf bird, curlew, rail, water chicken, mud hen, gallinule, shore birds, duck, goose, brant, swan	Jan. 1–Sept. 16.
ong Island (1908):	
Deer shooting permitted only on first two Wednesdays and Fridays after first Tuesday of November (Nov. 4, 6, 11, and 13 in 1908).	
Squirrel (black or gray), hare, rabbit	Jan. 1–Nov. 1.
Quail, grouse, woodcock	Jan. 1–Nov. 1.
Pheasants (English, Mongolian, ringneck), in Suffolk County	Jan. 1–Nov. 1.
Dove	All the year.
Wilson or English snipe, jacksnipe, surf snipe, winter snipe, yellowlegs, willet, plover, ringneck, killdeer, oxeye, curlew	Dec. 1–July 16.
Gallinule, meadow hen, mud hen	Jan. 1–Aug. 16.
Duck, goose, swan	Jan. 1–Oct. 1.
Brant	May 1–Oct. 1.
North Carolina [a] (1905):	
Deer	Feb. 1–Oct. 1.
Quail, wild turkey, dove, lark, robin	Mar. 1–Nov. 1.
North Dakota (1901):	
Deer	Dec. 1–Nov. 10.
Elk, moose, caribou, buffalo, sheep	All the year.
Antelope, 10 years	Until Jan. 1, 1911.
Quail, pheasants (English, Chinese), sharp-tailed grouse, ruffed grouse, pinnated grouse, prairie chicken, woodcock, swan	Oct. 15–Sept. 1.
Crane, duck, goose, brant	May 1–Sept. 1.
Ohio (1900–1908):	
Squirrel	Oct. 31–Oct. 1.
Rabbit	Dec. 5–Nov. 15.
Raccoon	Mar. 2–Nov. 1.
Quail	Dec. 5–Nov. 15.
Ruffed grouse, introduced pheasants, 5 years	Until Nov. 15, 1913.
Dove, woodcock	Dec. 5–Sept. 1.
Snipe, plover, shore birds, rail, coot or mud hen, duck, goose, swan	Jan. 1–Sept. 1.[b]
Oklahoma (1903):	
Deer, antelope	All the year.
Quail	Feb. 1–Oct. 15.
Grouse	All the year.
Prairie chicken, wild turkey	Jan. 1–Sept. 1.
Pheasants	Jan. 1–Dec. 1.
Dove, plover	Jan. 1–Aug. 1.
Oregon (1901–1907):	
Male deer (except in Baker, Coos, Curry, Grant, Harney, Malheur, Umatilla, Union, and Wallowa counties)	Nov. 1–July 15.
Coos and Curry counties	Oct. 15–July 15
Female deer (except in above counties)	Nov. 1–Sept. 1.
Coos and Curry counties	All the year

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[a] For seasons under county laws see Poster No. 18, "Close seasons for game, Maryl District of Columbia, Virginia, and North Carolina, 1908," which may be had upon a cation to the Biological Survey, U. S. Department of Agriculture, Washington, D. C.

[b] Except Mar. 1–Apr. 21; Sundays and Mondays are also closed seasons for ducks ther waterfowl.

Oregon (1901–1907)—Continued.	*Close seasons.*
Spotted fawn	All the year.
Elk	Oct. 15–Sept. 15.
Silver gray squirrel (*Sciurus fossor*)	Jan. 1–Oct. 1.
Partridge (English or gray), capercailzie, moor hen, pheasant (silver, golden, copper, green Japanese, and Reeves), wild turkey, woodcock	Dec. 1–Oct. 1.
Prairie chicken (see exceptions)	Until Sept. 15, 1909.
Exceptions: Wasco County — Oct. 15–Aug. 1	
Umatilla County — Dec. 1–Oct. 1	
Dove	All the year.
Upland plover, rail	Jan. 1–Aug. 1.
Duck, goose,[a] swan (except in Lake County, Apr. 1–Aug. 15, and in Coos County, Feb. 1–Aug. 1)	Feb. 1–Sept. 1.
West of Cascades.	
Quail, bobwhite, partridge, grouse, native pheasant (ruffed grouse), ringneck (China torquatus) pheasant (see exceptions)	Dec. 1–Oct. 1.
Exceptions:	
Tillamook County: Native pheasant (ruffed grouse), ringneck (China torquatus) pheasant — Dec. 1–Sept. 15	
Blue grouse — Oct. 15–Aug. 1	
Clatsop, Coos, Curry, and Josephine counties: Ringneck (China toquatus) pheasant — Dec. 1–Sept. 15	
Jackson County: Ringneck (China torquatus) pheasant — All the year	
East of Cascades:	
Quail (except in Wasco County, Oct. 15–Aug. 1, and Gilliam, Grant, Harney, Umatilla, and Wheeler counties, to Jan 1, 1912) hunting permitted only from second Saturday to third Tuesday in September (Sept. 12–15 in 1908).	
Native pheasant (ruffed grouse), grouse sage hen	Dec. 1–Aug. 15.
Pheasant	All the year.
Mongolian ringneck (China torquatus) pheasant (see exception)	Until Feb. 15, 1910.
Exception: Gilliam, Grant, Harney, Umatilla, and Wheeler counties — To Jan. 1, 1912	

Pennsylvania (1905–1907):	
Deer (deer without horns protected all the year)	Dec. 1–Nov. 15.
Bear	Mar. 1–Oct. 1.
Squirrel	Dec. 1–Oct. 1.
Hare, rabbit	Dec. 1–Oct. 15.
Quail	Dec. 1–Nov. 1.
Ruffed grouse (pheasant), woodcock	Dec. 1–Oct. 1.
Prairie chicken, imported pheasants (Chinese, English, Mongolian), wild turkey	Dec. 1–Oct. 15.
Wild pigeon	Until Apr. 22, 1915.
Dove, reedbird, rail, blackbird, sandpiper, tatler, curlew, or any shore bird	Jan. 1–Sept. 1.
Wilson snipe (jacksnipe)	May 1–Sept. 1.
Upland or grass plover	Dec. 1–July 15.
Coot or mud hen	Jan. 1–Sept. 1.[b]
Wild waterfowl—duck, goose, brant, swan, grebe	Apr. 10–Sept. 1.

Rhode Island (1900–1908):	
Deer	All the year.[c]
Gray squirrel, hare, rabbit	Jan. 1–Nov. 1.
Quail or bobwhite, ruffed grouse or partridge, woodcock	Jan. 1–Nov. 1.
Pheasant, 5 years	Until Oct. 15, 1910.
Dove	All the year.

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[a] Unlawful to kill geese at any time on islands or sand bars in the Columbia River east of the Cascades.

[b] Except Apr. 1–16.

[c] Tame deer kept in confinement may be killed by the owner at any time, or any deer injuring crops, by the owner or occupant of the premises under permit from secretary of state.

Rhode Island (1900–1908)—Continued.	*Close seasons.*
Plover, snipe, yellow legs, peep, shore, marsh, and beach birds	Jan. 1–Aug. 1.
Black duck and wood duck	Apr. 1–Aug. 15.
South Carolina (1902–1908):	
Deer (see exception)	Jan. 1–Sept. 1.
Exception: Beaufort, Berkeley, Charleston, Clarendon, Colleton, Darlington, Dorchester, Florence, Hampton, Horry, Kershaw, Marion, and Marlboro counties	Feb. 1–Aug. 1
Quail, partridge, pheasant, wild turkey, woodcock (see exception)	Mar. 1–Nov. 15.
Exception: Aiken, Barnwell, Beaufort, Berkeley, Charleston, Clarendon, Colleton, Dorchester, Fairfield, Georgetown, Hampton, Kershaw, Oconee, and Saluda counties	Apr. 1–Nov. 1
Mongolian pheasant, 4 years	Until Jan. 1, 1912.
South Dakota (1903–1905):	
Deer, elk, buffalo, sheep	Dec. 1–Nov. 1.
Antelope, 10 years	Until Jan. 1, 1911.
Quail, ruffed grouse, sharp-tailed grouse, pinnated grouse, prairie chicken, woodcock	Jan. 1–Sept. 1.
Dove	All the year.
Plover, curlew	May 15–Sept. 1.
Crane, duck, goose, brant	May 1–Sept. 1.
Tennessee (1903–1907):	
Deer (except Fentress County, Jan. 1–Dec. 1)	Until Oct. 1, 1911.
Squirrel	Mar. 1–June 1.[a]
Quail or partridge	Mar. 1–Nov. 15.
Grouse, pheasant (except English or ringneck pheasants), wild turkey,[b] meadowlark	Mar. 1–Nov. 1.
Pheasant, English or ringneck	Jan. 1–Dec. 1.
Dove (see exception), teal, wood (summer) duck	Apr. 15–Aug. 1.
Exception: Dove in Shelby County	Mar. 1–July 15
Robin, woodcock, snipe, sandpiper, plover, tatler, willet, godwit, curlew, avocet, marsh blackbird, rail, coot, mud hen, duck (except teal and wood duck), goose, brant, swan	Apr. 15–Oct. 1.
Texas (1907):	
Deer (female deer and spotted fawn protected all the year)	Jan. 1–Nov. 1.
Antelope, sheep, 5 years	Until July 1, 1912.
Quail or partridge, dove	Feb. 1–Nov. 1.
Prairie chicken or pinnated grouse, pheasants (Mongolian, English), 5 years	Until July 1, 1912.
Wild turkey	Apr. 1–Nov. 1.[c]
Utah (1907):	
Deer with horns (see exception)	Nov. 1–Oct. 1.
Exception: Nonresident not permitted to kill deer.	
Deer without horns, elk, antelope, sheep, any introduced game	Until Mar. 23, 1911.
Quail (see exceptions), pinnated grouse, pheasants (English, Mongolian, Chinese)	All the year.
Exceptions: Quail in Garfield, Kane, and Washington counties	Feb. 1–Aug. 1
Quail in Davis, Salt Lake, and Weber counties.	Oct. 26–Oct. 14

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[a] *Special squirrel seasons:* Benton, Decatur, Wilson, Jan. 1–June 1; Carroll, Mar. 1–June ; Carter, Mar. 1–July 15; Crockett, Weakley, Feb. 1–July 1; Fayette, Jan. 1–July 15; son, Sevier, Feb. 1–June 1; Hardeman, Feb. 15–July 15; Haywood, Jan. 1–May 1; nderson, Jan. 15–July 15; Lauderdale, Feb. 1–July 1; McNairy, Madison, Mar. 1–July , Robertson, Jan. 1–July 1; Shelby, Feb. 1–June 15; Stewart, Feb. 1–Aug. 1; Warren, r. 1–Oct. 1. Bedford, Blount, Cannon, Clay, Coffee, Cumberland, Dickson, Fentress, , Greene, Hickman, Humphreys, Jackson, Knox, Lawrence, Lincoln, London, Marshall, ry, Meigs, Moore, Overton, Perry, Pickett, Putnam, Rhea, Sequatchie, Sullivan, Van , Washington, Wayne, White, Williamson, unprotected.

Chester, Hardeman, Hardin, and McNairy counties anyone may kill squirrels on his property at any time for his own use.

cial *wild turkey seasons:* Lauderdale, Jan. 1–Nov. 1; Dyer (gobblers), May 1–Nov.) Feb. 1–Nov. 1; Clay, Fentress, Overton, Pickett, May 1–Aug. 1.

inion *of assistant* attorney-general of Texas dated Sept. 17, 1907.

Utah (1907)—Continued.	*Close seasons.*
Partridge, grouse, prairie chicken, sage hen, pheasant, mourning dove	Dec. 1–Aug. 1.
Snipe, shore birds, duck, goose, brant, swan	Jan. 1–Oct. 1.
Vermont (1894–1906):	
Deer	All the year except Oct. 26–31.[a]
Moose, caribou	All the year.
Gray squirrel	Dec. 1–Sept. 15.
Hare, rabbit	May 1–Sept. 15.
Quail, ruffed grouse or partridge, woodcock, English snipe, plover (other than upland)	Dec. 1–Sept. 15.
Pheasant, English partridge	Until Oct. 1, 1909.
Dove	All the year.
Upland plover	Dec. 1–Aug. 1.
Duck, goose	Jan. 1–Sept. 1.
Virginia[b] (1903–1908):	
Deer	Dec. 1–Sept. 1.
Squirrel:	
Alexandria County (gray)	Until Sept. 1, 1910
Isle of Wight and Southampton counties (gray or fox)	Jan. 15–Sept. 1
Rabbit	Feb. 1–Nov. 1.[c]
Opossum:	
Halifax County	Feb. 1–Oct. 15
Quail or partridge, pheasant or grouse, wild turkey, woodcock (see exceptions)	Feb. 1–Nov. 1.
Exceptions: West of the Blue Ridge	Jan. 1–Nov. 1
Accomac and Northampton counties (pheasant, grouse—5 years)	Until Mar. 14, 1909
Pheasants (English, Mongolian), 5 years	Until Jan. 1, 1909.
Robin	Apr. 1–Feb. 15.
Snipe (except Wilson and robin snipe), sandpiper, plover, surf bird, willet, tatler, curlew, rail (except sora), gallinule, mud hen	Jan. 1–July 20.
Summer or wood duck	Jan. 1–Aug. 1.
Winter waterfowl	May 1–Oct. 15.[d]
Washington[e] (1903–1907):	
Deer (see exceptions)	Dec. 15–Sept. 15.
Exceptions: Deer on islands, except those containing game preserves	Nov. 1–Oct. 1
Spotted fawn	All the year
Elk	Until Oct. 1, 1915.
Moose, caribou, antelope, sheep, goat (males)	Nov. 1–Sept. 15.
Moose, caribou, antelope, sheep, goat (females)	All the year.
Quail	Jan. 1–Oct. 1.
Bobwhite quail, Chinese or Mongolian pheasants in Okanogan County	Until Sept. 30, 1912
Partridge, grouse, prairie chicken, sage hen, native pheasant, ptarmigan (except east of Cascades, Nov. 15–Aug. 15; prairie chicken in Kittitas County, Oct. 1–Sept. 10)	Jan. 1–Sept. 1.
Pheasants (Chinese, Mongolian, or other imported pheasant)	Jan. 1–Oct. 1.
Dove	All the year.

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[a] Deer kept in private game preserves may be killed by the owners at any time.

[b] Boards of supervisors may shorten the open seasons in their counties and make other restrictions not repugnant to law "and may include in such protection other game not specifically mentioned in this section." Code 1904, sec. 2070a as amended in 1906.

[c] Residents of the State may kill rabbits on their own lands at any time.

[d] Wildfowl can not be hunted on Wednesdays and Saturdays on Back Bay, Princess Anne County.

[e] On Mercer Island, Lake Washington, game animals and birds are protected all the year.

Washington (1903–1907)—Continued.	*Close seasons.*
Snipe, sand-hill crane, duck, swan (see exception)	Mar. 1–Sept. 1.
Exception: Goose, brant, or other waterfowl on Columbia and Snake rivers, or within half a mile of their shores, in Columbia, Douglas, Franklin, Garfield, Klickitat, Kittitas, Wallawalla, Whitman, and Yakima counties—All the year	
Goose, brant (except as above)	May 1–Sept. 1.
Plover, rail	Mar. 1–Aug. 15.
West Virginia (1903):	
Deer (except spotted fawn, protected all the year)	Dec. 16–Oct. 15.
Squirrel, rabbit	Jan. 1–Sept. 15.
Quail or Virginia partridge	Dec. 20–Nov. 1.
Ruffed grouse, pheasant, pinnated grouse or prairie chicken, wild turkey	Dec. 15–Oct. 15.
Dove	All the year.
Woodcock	Nov. 2–July 15.
Snipe	July 1–Mar. 1.
Duck, goose, brant	Apr. 1–Oct. 1.
Wisconsin (1898–1907):	
Deer (see exceptions)	Dec. 1–Nov. 11.
Exceptions: Door County, 5 years — Until Nov. 11, 1912 Adams, Brown, Calumet, Columbia, Crawford, Dane, Dodge, Fond du Lac, Grant, Green, Green Lake, Iowa, Jefferson, Juneau, Kenosha, Kewaunee, La Crosse, Lafayette, Manitowoc, Marquette, Milwaukee, Monroe, Outagamie, Ozaukee, Racine, Richland, Rock, Sauk, Sheboygan, Vernon, Walworth, Washington, Waukesha, Waushara, and Winnebago counties — All the year	
Moose	All the year.
Squirrel (gray, black, fox), rabbit	Mar. 1–Sept. 1.
Quail, pheasants (Chinese, English, Mongolian), 8 years	Until Oct. 1, 1915.
Partridge, woodcock, snipe, plover	Dec. 1–Sept. 1.
Prairie chicken, grouse in Adams, Barron, Burnett, Buffalo, Chippewa, Clark, Crawford, Dodge, Dunn, Eau Claire, Grant, Iowa, Jackson, Juneau, Lafayette, Marquette, Monroe, Pepin, Polk, Portage, Richland, Rusk, Sawyer, St. Croix, Vernon, Washburn, Waushara, and Wood counties — Oct. 15–Oct. 1	
Prairie chicken, grouse in rest of State — Until Sept. 2, 1915	
Turtle dove, swan	All the year.
Rail or rice hen, duck, coot or mud hen	Jan. 1–Sept. 1.
Goose, brant	May 1–Sept. 1.
Wyoming (1903–1907):	
Deer, elk, antelope, sheep	Nov. 15–Sept. 15.
Moose, 9 years	Until Sept. 15, 1912.
Quail (bobwhite, California, Mexican), Mongolian pheasant, 5 years	Until Sept.1, 1912.
Partridge, grouse, prairie chicken, sage chicken	Sept. 15–Aug. 1.
Dove, swan	All the year.
Snipe, plover, green-shank, tatler, godwit, curlew, avocet, or other wader, duck, goose, brant	May 1–Sept. 1.
Alberta[a] (1906–1908):	
Deer, moose, caribou	Dec. 1–Nov. 1.
Elk or wapiti	Until Nov. 1, 1910.
Antelope	Nov. 1–Oct. 1.
Buffalo	All the year.
Sheep, goat	Until Oct. 1, 1909.
Grouse, partridge, prairie chicken, ptarmigan, pheasant (except English)	Nov. 1–Sept. 15.[b]
English pheasant	All the year.
Crane, snipe, sandpiper, plover, curlew, shore bird, rail, coot	Jan. 1–Sept. 1.[c]
Duck,[c] swan	Jan. 1–Aug. 23.

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[a] North of latitude 55° any game animal or bird except elk and buffalo may be killed [illegible] time if needed for food.

[illegible] the season will be Nov. 1–Oct. 1.

[illegible] winged scoters, which may be taken at any time north of Township 50.

	Close seasons.
British Columbia [a] (1898–1908):	
Deer (except fawns), sheep (except ewes and lambs), goat	Dec. 15–Sept. 1.
Fawns, ewes, and lambs	All the year.
Bull elk or wapiti, bull moose, bull caribou, hare	Jan. 1–Sept. 1.
Females and young of elk, moose, and caribou	All the year.
Quail, English partridge, pheasant, swan, and all imported game birds	All the year.
Grouse, prairie chicken, ptarmigan (see exception)	Jan. 1–Sept. 1.
Exception: Grouse and ptarmigan north of latitude 55° — Apr. 1–Sept. 15	
Snipe, plover, duck (see exception)	Mar. 1–Sept. 1.
Exception: Duck, north of latitude 55° — Apr. 1–Sept. 15	
Manitoba (1902–1908):	
Deer, elk or wapiti, moose, caribou or reindeer, antelope or cabri (males)	Dec. 15–Dec. 1.
Females and young of foregoing species and bison or buffalo	All the year.
Quail, woodcock, snipe, sandpiper, plover (except upland plover)	Jan. 1–Aug. 1.
Grouse, partridge, prairie chicken	Nov. 1–Oct. 15.
Dove	All the year.
Pheasant, 5 years	Until Oct. 1, 1909.
Upland plover	Jan. 1–July 1.
Duck	Dec. 1–Sept. 1.
New Brunswick (1899–1907):	
Deer, moose, caribou (cow and calf moose and cow caribou all the year)	Dec. 1–Sept. 15.
Partridge	Dec. 1–Sept. 15.
Pheasant	All the year.
Woodcock, snipe, teal, wood duck, dusky or black duck, goose, brant	Dec. 2–Sept. 1.
Shore or other birds on beaches, islands, or lagoons bordering tidal waters of Northumberland Strait, Gulf of St. Lawrence, and Bay of Chaleur	Jan. 1–Sept. 1.
Newfoundland [b] (1902–1908):	
Elk, moose, 10 years	Until Jan 1, 1912.
Caribou (except in a special region near Grand Lake, all the year)	Feb. 1–Aug. 1.[c]
Rabbit, hare	Dec. 15–Oct. 1.[d]
Ptarmigan, willow grouse or partridge, snipe, plover, curlew, or "other wild or migratory birds (except wild geese)"	Dec. 15–Oct. 1.
Capercailzie, black game, 10 years	Until Oct. 12, 1917.
Nova Scotia (1900–1908):	
Deer, caribou, 4 years	Until Oct. 1, 1912.
Moose (see exceptions)	Dec. 1–Oct. 1.
Exceptions: Cape Breton Island — Until Oct. 1, 1915	
Calf moose under 1 year — All the year	
Hare, rabbit	Mar. 1–Nov. 1.
Ruffed grouse or birch partridge	Nov. 1–Oct. 1.

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[a] The lieutenant-governor is empowered to make further restrictions in these seasons. Resident Indians (nonresidents not allowed to hunt) and farmers in "unorganized districts" may kill deer for immediate use as food, but Indians can kill does and fawns only Aug. 1–Feb. 1; free miners while engaged in placer mining or prospecting in unorganized districts, and surveying or engineering parties engaged in their duties may kill any game for food. The following special seasons have been made by orders in council: In the Okanagan electoral district prairie chickens, willow grouse, and blue grouse are protected until September 1, 1910; in the Lillooet and Cariboo electoral districts the open season for mountain sheep closes November 14 in each year; in the East Kootenay district moose are protected all the year; south of the Canadian Pacific Railway, from the coast to Columbia River and from Revelstoke to the International Boundary, sheep are protected all the year; and in that part of the Lillooet district known as the Yalakom Mountain district (game reserve) all protected animals and birds and also geese are protected absolutely until October 4, 1917.

[b] Poor settlers may kill any birds, except capercailzie and black game, at any time, for immediate consumption by themselves or their families.

[c] Additional close season Oct. 1–21.

[d] Snaring or trapping prohibited Mar. 1–Oct. 1.

Nova Scotia (1900–1908)—Continued.	*Close seasons.*
Canada grouse (spruce partridge), chukar partridge, pheasant, capercailzie, black game	All the year.
Quail, sharp-tailed grouse, ptarmigan, heron, bittern, woodcock, plover, snipe, sandpiper, yellowlegs, curlew, beach birds, waders, teal, blue-winged duck (see exception) wood duck	Mar. 1–Sept. 1.
Exception: Cumberland Co. (blue-winged duck) May 1–Sept. 1	
Pheasant	All the year.
Ontario[a] (1907) :	
Deer (young protected all the year)	Nov. 16–Nov. 1.[b]
Elk or wapiti	All the year.
Moose, caribou, or reindeer (see exception)	Nov. 16–Oct. 16.[c]
Exception: Female moose and young moose and caribou All the year	
Squirrel (black or gray)	Dec. 2–Nov. 1.
Hare[d]	Jan. 1–Oct. 1.
Quail, wild turkey	Dec. 2–Nov. 1.
Prairie fowl, woodcock	Dec. 16–Sept. 15.
Grouse, partridge, capercailzie	Until Sept. 15, 1909.
Pheasants (English or Chinese), 3 years	Until Sept. 15, 1910.
Snipe, plover, rail, other shore birds or " waders "	Dec. 16–Sept. 1.
Dove	All the year.[e]
Goose, swan	May 1–Sept. 15.
Duck and other waterfowl (except goose and swan)	Jan. 1–Sept. 1.
Prince Edward Island (1906–1907) :	
Hare, rabbit	Mar. 1–Sept. 1.
Partridge	Dec. 1–Oct. 1.
Plover, curlew	Jan. 1–July 15.
Woodcock, snipe	Jan. 1–Sept. 1.
Yellowlegs, shore and other birds along beaches or tidal marshes, teal, black, or bluewinged duck	Jan. 1–Aug. 20.
Goose	May 10–Sept. 15.
Brant	June 10–Oct. 1.
Quebec (1899–1908) :	
Zone 1.[f] Deer, moose (see exceptions)	Jan. 1–Sept. 1.
Exceptions: In Ottawa and Pontiac counties Dec. 1–Oct. 1	
Cow moose and young deer and moose All the year	
Caribou (young protected all the year)	Feb. 1–Sept. 1.
Hare	Feb. 1–Dec. 1.
Bear	July 1–Aug. 20.
Birch or swamp partridge	Dec. 15–Sept. 1.
White partridge or ptarmigan	Feb. 1–Nov. 1.
Woodcock, snipe, sandpiper, plover, tatler, curlew	Feb. 1–Sept. 1.
Widgeon, teal, duck (except sheldrake), loon, gull	Mar. 1–Sept. 1.[g]
Zone 2. Close seasons same as in Zone 1, except as follows:	
Caribou	Mar. 1–Sept. 1.
Hare	Mar. 1–Oct. 15.
Birch or swamp partridge	Feb. 1–Sept. 15.
White partridge or ptarmigan	Mar. 1–Nov. 15.

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[a] Lieutenant-governor in council may alter close seasons in region north and west of French River, Lake Nipissing, and Mattawa River, and in the vicinity of Rondeau Park, and close for a definite period seasons for any game animal or nonmigratory game bird whose numbers have diminished.

[b] Persons who put or breed deer on their own lands, and their licensees, may hunt such deer Oct. 1–Nov. 16.

[c] South of the Canadian Pacific R. R., between Mattawa and the Manitoba boundary, Nov. 16–Nov. 1.

[d] Cottontail rabbits (wood hares) may be killed during close season when damaging trees or shrubs.

[e] Under act for protection of insectivorous birds, Rev. Stats. 1897, ch. 289, sec. 3.

[f] Zone No. 1 comprises the whole Province, except that part of the counties of Chicoutimi and Saguenay east and north of the river Saguenay. Zone No. 2 comprises the excepted part of said counties.

[g] Inhabitants of Zone 2 and Gaspé County may take these birds for food at any season except June 1–Aug. 1.

	Close seasons.
Saskatchewan[a] (1905–1907):	
Deer, elk or wapiti, moose, caribou (females and young all the year)	Dec. 15–Dec. 1.
Antelope (young all the year)	Nov. 15–Oct. 1.
Buffalo	All the year.
Grouse, partridge, prairie chicken, ptarmigan	Dec. 1–Sept. 15.
English pheasant	All the year.
Crane	Jan. 1–Aug. 1.
Snipe, sandpiper, plover, curlew, shore birds, rail, coot, duck, goose, swan	Jan. 1–Sept. 1.
Unorganized Territories[b] (Keewatin, Mackenzie, etc.), (1894–1906):	
Deer, elk or wapiti, moose, caribou, goat	Apr. 1–Dec. 1.[c]
Buffalo	To Jan. 1, 1912.
Musk ox	Mar. 20–Oct. 15.
Grouse, partridge, prairie chicken, pheasant	Jan. 1–Sept. 1.
Duck, goose, swan	Jan. 15–Sept. 1.
Yukon[d] (1902–1906):	
Deer, elk or wapiti, moose, caribou, sheep, goat, musk ox	Mar. 1–Sept. 1.
Bison or buffalo	All the year.
Grouse, partridge, prairie chicken, ptarmigan, pheasant	Mar. 15–Sept. 1.
Snipe, sandpiper, crane, duck, goose, swan	June 1–Aug. 10.

SHIPMENT OF GAME.

Shipment is the most important feature of the traffic in game. It has, likewise, a marked effect upon the perpetuation of game, and when permitted without limitation is a great factor in its rapid destruction. A realization of this fact has induced many of the States to prohibit export of all or certain kinds of game and in a few instances all transportation even within the State. The subject may be conveniently considered under the following subheads: "Federal laws," "Marking packages," and "State laws prohibiting export."

FEDERAL LAWS.

Federal laws affecting the shipment of game comprise the statutes regulating interstate commerce in game and the importation of birds from foreign countries and those providing for the protection of birds and game on territory under the immediate jurisdiction of the United States.

They comprise: (1) The Lacey Act, regulating the importation of game and its shipment from one State to another; (2) the tariff act, imposing duties on game, skins, and feathers imported from foreign countries; (3) the act regulating the introduction of eggs of game birds; (4) the game law of Alaska, and (5) provisions for protecting birds in the National parks,[a] National forests, and other Government reservations. These laws are more fully discussed in Bulletin No. 16 of the Biological Survey, entitled "Digest of Game Laws for 1901" (pp. 69–79). The full text of several may be found in various circulars published by the Biological Survey: Circular No. 29 (1900) contains the Lacey Act, and Circular No. 66 (1908), the new Alaska game law, with the regulations now in force.

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[a] Lieutenant-governor in council may extend close seasons over current year within limits on petition of 6 game guardians.

[b] Indians, inhabitants, and travelers, explorers, and surveyors in need of food exempt. Governor in council may alter seasons.

[c] Except July 15–Oct. 1.

[d] Indians, explorers, surveyors, prospectors, miners, and travelers in need of food are exempt. Commissioner in council may alter seasons.

MARKING PACKAGES.

Section 4 of the Lacey Act requires every package containing game animals or birds when shipped in interstate commerce to be clearly marked so as to show the name and address of the shipper and the nature of the contents. The laws of Colorado, Connecticut, Louisiana, Michigan, Mississippi, Montana, Nebraska, New York, North Carolina, Ohio, Oregon, South Carolina, Wisconsin, New Brunswick, and Ontario likewise require each package of fish or game to bear a statement indicating the contents. Such general statements as "game" or "birds" are not sufficient to show the nature of the contents; the *kind* of game should be shown, and also the *amount* in the package.

Some of the State laws are very explicit on the subject of marking. Nebraska requires all packages to be labeled with the address of the consignor and the amount of each kind of game contained in the package, and provides a fine of $10 to $50 for omission of these details. Ohio and North Carolina have similar requirements. Michigan and New York require all packages of game to be plainly marked on the outside with the names of the consignor and consignee, the initial point of billing and destination, and an itemized statement of the quantity of game contained therein. South Carolina requires the names of consignor, consignee, and owner, and a description of the contents. Wisconsin's requirements are similar, and heavy penalties are provided for violation. Mississippi directs that the package bear the names of consignor and consignee and an itemized statement of the species of game, and further provides that the contents must be packed so as to be readily seen. In Louisiana and Ontario packages must also be made so as to show the contents, besides bearing, on the outside, a description of the contents and the names and addresses of owners. Several States require big game and game birds carried by sportsmen to be marked with the owner's name, shipped as baggage, and transported open to view.

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[a] The law governing the Yellowstone Park prohibits any person, or any stage, express or railway company from receiving for transportation animals, birds, or fish taken in the park, under a penalty not exceeding $300. (28 Stat. L., ch. 72, sec. 4.)

Railroad and express companies should call the attention of their agents to these provisions, and insist that all packages be properly marked before shipment. In Nebraska, New York, South Carolina, and Wisconsin common carriers are prohibited, under heavy penalties, from receiving consignments of game not properly labeled. In Texas they may examine suspected packages, and in Arkansas they may cause them to be opened when necessary, and may refuse packages supposed to contain fish or game for export. In Michigan and Wisconsin packages of fish or game may be opened by game wardens, and if not properly marked may be confiscated.

STATE LAWS PROHIBITING EXPORT.

Since the constitutionality of the Connecticut statute prohibiting export of certain game was established by the Supreme Court in 1896[a] nonexport laws have been generally adopted, and at the present time every State prohibits the export of certain kinds of game. (See fig. 3, p. 37.) In some States sportsmen are allowed to carry a limited amount of game out of the State under special restrictions, and exceptions to the laws prohibiting export are also made in the case of birds and animals intended for propagation.

Restrictions on shipment from the State have now become so stringent that all the States and Territories west of the Mississippi River except two prohibit export of all game protected by local laws. Of the two exceptions, Iowa prohibits export of all game but shore birds, and Wyoming export of certain species. East of the Mississippi similar laws are in force in nearly all of the States north of the Ohio and Potomac rivers, and also in Alabama, Mississippi, Tennessee, Virginia, and West Virginia. The export of most if not all protected game taken within the State is prohibited in all these States except Massachusetts, Rhode Island, Connecticut, New Jersey, Delaware, Maryland, and Illinois, and in these export of certain kinds of game is illegal.

Deer can be lawfully exported from only six States—Delaware (where they do not occur), Georgia, Kansas, Kentucky, North Carolina, and Ohio. The export of deer hides is specially prohibited by the laws of Alaska, California, Florida, Minnesota, Wyoming, British Columbia, and Ontario; Wisconsin limits the export of green hides to the period from November 13 to December 3 of each year; Washington and British Columbia prohibit killing deer for hides; Oregon makes all hunting for hides dependent on permission of the State game and forestry warden; and New Brunswick and Newfoundland allow shipment of green hides only under license.

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[a] Geer v. Connecticut, 161 U. S., 519.

Among game birds the most general prohibition is that of the export of quail, which is now in force in every State and Territory, with two exceptions. In one of the excepted States, Wyoming, quail do not occur; in the other, Maryland, several counties prohibit their export. A number of States permit imported birds to be exported, however, and Colorado, Illinois, and Montana allow quail to be shipped from the State under permit. Besides these exceptions, 23 States, including Oregon (see table), permit nonresident hunters to take a limited number of birds out of the State; Maine, Montana, South Dakota, Vermont, Virginia, Wyoming, Alberta, British Columbia, Manitoba, and New Brunswick grant the same privilege to resident hunters.

Special attention is called to the following table, which contains a list of the game prohibited from export by each State and Territory:

Export of Game Prohibited.

Alabama:

Deer, squirrel, quail or partridge, ruffed grouse or pheasant, imported pheasant or other imported game bird, wild turkey, dove, rail, coot or mud hen, woodcock, snipe, sandpiper, plover, curlew, shore birds, duck, goose, brant, swan.

Exceptions: Nonresident licensee may take with him or have carried to him, openly, game lawfully killed by him. State game and fish commissioner may issue permit to any person to capture, kill, or export game birds at any time, dead or alive, for scientific or propagating purposes.

Alaska:

Deer, moose, caribou, sheep, goat, bear, or hides of these animals; wild birds, except eagles, or any parts thereof.

Exceptions: Specimens may be exported under restrictions imposed by the Secretary of Agriculture, and trophies of big game under licenses issued by the Governor.[a]

Arizona:

Deer, elk, antelope, sheep, goat, quail, bobwhite, partridge, grouse, pheasant, wild turkey, snipe, rail, duck, goose, brant.

Arkansas:

Deer (unless raised in captivity), wild turkey, wild fowl, game of any description except rabbits, which must be shipped open to view. (Squirrels cannot be shipped out of Craighead, Dallas, Lafayette, and White counties.)

California:

Deer, deerskins, quail, partridge, grouse, prairie chicken, sage hen, pheasant, dove, wild pigeon, shore birds, plover, snipe, rail, curlew, ibis, duck.

Colorado:

Deer, elk, antelope, bison, buffalo, sheep, quail, partridge, grouse, ptarmigan, prairie chicken, sage chicken, pheasant, wild turkey, dove, pigeon, snipe, plover, curlew, shore birds, crane, duck, goose, brant, swan, waterfowl.

Exception: Game may be exported under permit from game commissioner if permit be attached and package plainly marked so as to show nature of contents. The following fees are charged for export permits: Elk, $10; deer, $5; antelope, $5.

Connecticut:

Quail, ruffed grouse, woodcock.

Delaware:

Rabbit, quail, partridge, woodcock (nonresidents also prohibited from shipping English snipe).

Florida:

Deer, deer hides, quail or partridge, wild turkey from county.

Georgia:

Quail or partridge.

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[a] See p. 49 and also Circular No. 66, Biological Survey, U. S. Department of Agriculture, 1908.

aho:

Deer, elk, moose, caribou, antelope, buffalo, sheep, goat, quail, partridge, grouse, prairie chicken, sage hen, pheasant, Mongolian pheasant, dove, snipe, plover, duck, goose, swan.

Exception: Any hunter may export, under hunting license, animals lawfully taken; but each shipment must be accompanied by a sworn statement of number and date of license and fact that game was not procured contrary to law.

linois:

Squirrel, quail, ruffed grouse, pinnated grouse, prairie chicken, pheasant, wild turkey, duck, goose, brant, taken in the State.

Exceptions: Game may be exported under license from the State. Nonresident may take from State 50 birds killed by himself, if carried openly for inspection.

ndiana:

Deer, quail, grouse, prairie chicken, pheasant, wild turkey, woodcock, duck, goose, brant, and other waterfowl.

Exception: Nonresident may take from State 15 birds killed by himself, if carried openly for inspection, together with his license, or 45 if he has hunted for 3 or more days consecutively.

Iowa:

Squirrel, quail, ruffed grouse, pinnated grouse, prairie chicken, pheasant, wild turkey, woodcock, duck, goose, brant.

Exception: Nonresident may take from State not more than 25 game birds or animals killed by himself, if carried openly for inspection.

Kansas:

Quail, partridge, grouse, prairie chicken, pheasant, dove, plover, duck, goose, brant.

Kentucky:

Quail, partridge, grouse, pheasant, wild turkey, killed in the State.

ouisiana:

Deer, quail, grouse, prairie chicken, wild turkey, imported pheasant, dove, woodcock, snipe, sandpiper (chorook, papabotte), plover, tatler, curlew, rail (mud hen), gallinule, coot (poule d'eau), duck, goose, brant, alive or dead.

Exception: A sportsman may carry with him out of the State 1 deer and a limited number of birds of each kind, but not for sale.

aine:

Deer, moose, quail, ruffed grouse, pheasant, capercailzie, black game, plover, woodcock, snipe, sandpiper, wood duck, dusky or black duck, teal, gadwall or gray duck, mallard, widgeon or baldpate, shoveler, pintail or sprigtail, redhead, scaup or greater bluebill, lesser scaup or lesser bluebill, golden-eye or whistler, buffiehead, ruddy duck or broadbill.

Exceptions: A resident of the State may export 1 deer in a season if open to view, tagged to show name and address of owner and accompanied by him, and under shipping license 1 moose, 6 partridges, 10 woodcock, and 10 ducks lawfully killed by himself. A nonresident may export under hunting license 1 moose and 2 deer lawfully killed by himself and may take home 10 partridges, 10 ducks, and 10 woodcock. Any person may export a pair of game birds under a special 50-cent license.

Maryland: *County provisions, as follows:*

Allegany—All game, viz:—Deer, squirrel, rabbit, partridge or quail, pheasant, turkey, woodcock, duck, goose, brant, swan from county.

Anne Arundel—All game, viz:—Squirrel, rabbit, quail, partridge, pheasant, woodcock, snipe, plover, duck, goose, brant, swan from county.

Baltimore—Partridge, pheasant, woodcock from county.

Calvert—Rabbit, partridge, woodcock from county (for sale, barter, or trade).

Caroline—Rabbit, quail, partridge, woodcock from county.

Dorchester—Squirrel, rabbit, quail, partridge, woodcock, dove (for sale).

Exception: Twelve quail or partridges, 6 squirrels, rabbits, woodcock, and doves may be taken out of the county as personal baggage, if carried openly and not intended for sale.

Frederick—Squirrel, partridge, pheasant, woodcock from county (for sale).

Garrett—Partridge (quail), pheasant, wild turkey, woodcock from county.

Exception: Nonresident may take out game killed under his hunting license.

Kent—Squirrel, rabbit, and all birds from county (for sale, except under license).

Montgomery—Partridge, pheasant, wild turkey from county (for [illegible]

Queen Anne—Rabbit, partridge, woodcock from county (for [illegible]

Somerset—All game, viz:—Squirrel, rabbit, quail or [illegible] cock, duck, goose from county.

Maryland—Continued.

Washington—Deer, squirrel, rabbit, partridge, pheasant, woodcock, wild turkey from county (for sale).

Wicomico—Quail or partridge from Wicomico and Worcester counties considered as one territory.

Worcester—Rabbit, quail, woodcock from county.

Massachusetts:

Quail, ruffed grouse, woodcock taken in the State; other game illegally taken in the State.

Exception: Nonresident may take 6 birds out of the State under his hunting license.

Michigan:

Deer, elk, moose, caribou, squirrel, quail, partridge, ruffed grouse, prairie chicken, spruce hen, Manitoba grouse, ptarmigan, Mongolian or English pheasant, wild turkey, dove, pigeon, snipe, plover, woodcock, duck, goose, brant, and other wild waterfowl.

Exceptions: (1) Game consigned to a point within the State may be transported outside the State if necessary to reach destination.

(2) Nonresident licensee may take out 1 deer under permit from State warden.

(3) Landowners and members of clubs owning game preserves may ship during open season under a $10 permit from State warden 50 ducks or other migratory birds lawfully killed by them on their own premises.

Minnesota:

Deer, elk, moose, caribou, hide or horns thereof, quail, partridge, ruffed grouse, prairie chicken, pinnated grouse, sharp-tailed or white-breasted grouse, ringneck or English pheasant, dove, snipe, duck, goose, brant, or any aquatic fowl.

Exception: Nonresident licensee may ship home in open season, under his license coupons, 1 deer and 25 birds lawfully taken by himself.

Mississippi:

Deer, bear, quail or partridge, wild turkey, dove, plover, tatler, chorook, grosbec, coot (poule d'eau), rail (mud hen), duck, goose, brant, swan.

Missouri:

Deer, squirrel, quail, pinnated grouse, prairie chicken, ruffed grouse, pheasant, wild turkey, dove, woodcock, snipe, plover, duck, goose from county.

Exceptions: Any person may take 1 deer, 2 wild turkeys, 25 quail, and 25 ducks, lawfully killed by him, to his residence by the usual manner of travel. Deer or elk from private preserves may be exported dead or alive under a special 50-cent permit from the county game warden.

Montana:

Deer, elk, moose, buffalo, sheep, goat, quail, pheasant or partridge, prairie chicken, fool hen, sage hen, grouse, Chinese pheasant, duck, goose, brant, swan.

Exception: Game lawfully killed may be exported during the open season if accompanied by the owner, and when shipped by resident of State, by permit from State game and fish warden, or when shipped by nonresident of State, by hunting license; total shipment under one license not to exceed number allowed to be killed in one season; all packages to be plainly labeled to show nature of contents.

Nebraska:

Deer, elk, antelope, quail, partridge, pheasant, grouse, ptarmigan, prairie chicken, sage chicken, wild turkey, pigeon, dove, snipe, plover, yellowlegs, curlew, crane, duck, goose, brant, swan.

Exception: Nonresident may ship 50 birds out of State under hunting license, but must give common carrier invoice of number and kind of birds, must have details of shipment marked on license, and must accompany the shipment.

Nevada:

Deer, elk, antelope, caribou, sheep, goat, quail, grouse, pheasant, sage chicken, prairie chicken, dove, woodcock, snipe, plover, curlew, sandhill crane, duck, goose.

New Hampshire:[a]

Elk, moose, caribou, quail, partridge, ruffed grouse, pheasant, woodcock, Wilson snipe, dove, plover, yellowlegs, sandpiper, rail, duck (except sheldrake), and all "beach" birds.

Exception: Nonresident may export, under his hunting license, 2 deer and 12 birds, carried open to view, on notice of number and kind to the commissioner who issued the license.

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[a] ***Blue Mountain*** Forest Association permitted to ship deer, elk, and moose killed in its

New Jersey:

Squirrel, hare, rabbit, quail or partridge, ruffed grouse or pheasant, pinnated grouse, English pheasant, ringneck pheasant, woodcock.

Exception: English or ringneck pheasants killed on preserves established prior to April 15, 1903, may be exported from the State.

New Mexico:

Deer, elk, antelope, sheep, native or crested quail, bobwhite quail, partridge, mountain grouse, prairie chicken, pheasant, ptarmigan, wild turkey, turtle dove, wild pigeon for market.

New York:

Game or birds taken in the State, including deer (excepting head, feet, and skin), elk, antelope, moose, caribou, squirrel, hare, rabbit, quail, grouse, Mongolian and English pheasants, plover, Wilson or English snipe, woodcock, curlew, shore birds, rail, mud hen, gallinule, water chicken, duck, goose, brant, or swan.

Exception: Nonresident may export 1 deer under his hunting license.

North Carolina:*

Quail, partridge, pheasant, grouse, wild turkey, snipe, shore or beach bird, woodcock, taken in State.

Exception: Nonresident may take out of State under his hunting license 50 quail (partridges), 12 grouse, 2 turkeys, and 50 beach birds or snipe in a season.

North Dakota:

Deer, elk, moose, caribou, antelope, buffalo, sheep, quail, ruffed grouse, prairie chicken, pinnated grouse, sharp-tailed grouse, English or Chinese pheasant, woodcock, crane, duck, goose, brant, swan.

Ohio:

Squirrel, quail, ruffed grouse or pheasant, introduced pheasant, dove, woodcock, plover, snipe, shore birds, rail, coot (mud hen), duck, goose, swan taken in the State.

Exception: Nonresident may take with him from State under his hunting license 50 pieces of game.

Oklahoma:

Deer, antelope, quail, grouse, prairie chicken, imported pheasant, wild turkey, dove, plover.

Oregon:

Deer, antelope, elk, moose, sheep (or hides of said animals), quail or bobwhite, English or gray partridge, capercailzie, moor hen, grouse, sage hen, pheasant; Mongolian, silver, golden, copper, green Japanese, and Reeves pheasants; prairie chicken, wild turkey, woodcock, rail, upland plover, duck, goose, swan, or other wildfowl.

Exception: Any citizen of Washington may take one day's bag with him out of the State.

Pennsylvania:

Deer, squirrel, hare, rabbit, quail, partridge, grouse, pheasant; English, Mongolian, or Chinese pheasant; wild turkey, reedbird, plover, woodcock, rail, web-footed wildfowl, taken in State.

Rhode Island:

Quail, ruffed grouse, woodcock.

South Carolina:

Deer, quail, partridge, grouse, pheasant, wild turkey, woodcock, snipe, and other game birds or animals taken in the State.

Exception: Licensee may carry openly 2 deer, 50 partridges, 12 ruffed grouse, 4 wild turkeys, 50 beach birds, 50 ducks and geese in a season.

South Dakota:

Deer, elk, antelope, buffalo, sheep, quail, ruffed grouse, prairie chicken, pinnated grouse, sharp-tailed grouse, plover, curlew, woodcock, crane, duck, goose, brant.

Exception: Two deer, 1 elk, 1 buffalo, 1 mountain sheep, and not more than 15 birds not intended for commercial purposes may be shipped in open view during open season and 3 days thereafter, when tagged and accompanied by owner. In the case of big game, a certificate—good for 5 days—that such game was lawfully killed must be obtained from a justice of the peace and given to the carrier.

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* The following county laws are also in force: Brunswick, Dare, New Hanover—Wild fowl, March 10–November 10 from county. Catawba, Iredell, Surry, Swain—Quail from county.

Tennessee:

All State game, viz: Deer, squirrel, quail, partridge, grouse, prairie chicken, pheasant, wild turkey, marsh blackbird, dove, meadowlark, robin, plover, snipe, woodcock, sandpiper, tatler, willet, curlew, godwit, avocet, rail, coot, mud hen, duck, goose, swan, brant.

Exception: Nonresident may take with him from the State 50 ducks or 30 pieces of other game, but must present to some officer or employee of common carrier his hunting license and sworn statement that his game is not for sale and will not be sold.

Texas:

All wild animals, wild birds, and wild fowl found in the State, including deer, antelope, mountain sheep, quail or partridge, grouse, pinnated grouse or prairie chicken, Mongolian or English pheasant, wild turkey, dove, pigeon, plover, snipe, jacksnipe, curlew, duck, goose.

Exception: Nonresident licensee may take one day's bag out of State.

Utah:

Deer, elk, antelope, sheep, quail, partridge, prairie chicken, sage hen or grouse, pinnated grouse, pheasant, Mongolian, Chinese, or English pheasant, dove, snipe, shore bird, duck, goose, brant, swan, or any introduced game animal or bird.

Vermont:

Deer, gray squirrel, quail, ruffed grouse or partridge, plover, English snipe, woodcock, duck, goose.

Exception: One deer may be exported during the open season and 10 days thereafter by a resident, if shipped open to view, properly labeled with the name of the owner and accompanied by him; and by a nonresident when his license, with shipping coupons attached, is presented to the transportation company.

Virginia:

Deer, venison, quail or partridge, pheasant or grouse, wild turkey, woodcock, plover, snipe, sandpiper, surf-bird, curlew, willet, tatler, rail (except sora), mud hen, gallinule, waterfowl.

Exceptions: During open season nonresident may, under his hunting license, take with him out of the State, or as baggage on the same conveyance, 1 deer, 50 quail or partridges, 10 pheasants or grouse, 3 wild turkeys, 30 waterfowl, and 25 of each, or 100 in all, of plover, snipe, sandpipers, willets, tatlers, and curlew, if killed or captured by himself, and shipped open to view and plainly labeled with his name and address. Any citizen of State may ship from the State, as a gift and not for sale (which fact must be stated on shipping tag), 1 deer, 18 quail or partridges, 6 pheasants, 3 wild turkeys, and 12 waterfowl, if open to view and plainly labeled with names and address of donor and donee, and number of each kind of bird so shipped.

Washington:

Deer, elk, moose, caribou, antelope, sheep or goat, quail, partridge, grouse, prairie chicken, sage hen, pheasant, ptarmigan, plover, rail, sandhill crane, snipe, duck, goose, brant, swan or any other game animal or bird of the State, including introduced bobwhite, California valley quail, mountain quail, and Old World pheasants.

Exception: Nonresident may export one season's limit of big game and one day's bag limit of birds under his hunting license, if accompanied by affidavit that the game was killed by him and is not for sale.

West Virginia:

Deer, quail, pheasant, ruffed grouse, wild turkey.

Wisconsin:

Deer, quail, partridge, grouse, prairie chicken, pheasant, Mongolian, Chinese, or English pheasant, dove, woodcock, plover, snipe, rail, wild duck, goose, brant, swan, or other aquatic fowl.

Exception: During open season nonresident may take out of State under his hunting license, in personal possession or as baggage or express, accompanying same to State line, 1 deer and not more than 30 game animals and birds of all kinds, provided packages are plainly marked so as to show the names and addresses of shipper and consignee and number of each kind of game, and, in case of deer, have proper coupons attached.

Wyoming:

Deer, elk, moose, antelope, mountain sheep, or green hides, teeth, or horns of any of said animals.

Exceptions: Smithsonian Institution or other well-known scientific institutions may export any game animals or birds, under permit of State game warden; mounted heads and stuffed specimens may be shipped out of State.

Export of 1 hide, 1 scalp, 1 head, and 1 pair of tusks of any big game except moose permitted upon affidavit that they were taken from animals lawfully killed and the payment of 25 cents to the justice of the peace of precinct where affiant lives and attachment of the tag issued by him; and a nonresident (or resident, when necessary to cross territory of another State to reach his home) may export under his hunting license carcasses, heads, antlers, scalps, skins, and teeth of any animals lawfully killed.

Alberta:

Deer, elk, moose, caribou, antelope, buffalo, sheep, goat, partridge, grouse, prairie chicken, ptarmigan, pheasant, snipe, sandpiper, plover, curlew, shore bird, rail, coot, crane, duck, goose, swan.

Exceptions: Minister of Agriculture on receipt of a $5 fee may grant a permit to export for propagation or scientific purposes one pair of each species of big game and game birds. The Lieutenant-Governor in council may grant permits for a greater number. The Minister of agriculture may also issue permits for export of game for other purposes at the rate of $5 for each head of big game and $1 per dozen for game birds. The holder of a general nonresident license may take with him out of the Province as trophies, heads, skins, and hoofs of big game legally killed by him.

British Columbia:

Deer, elk, moose, caribou, sheep, goat, hare, quail, partridge (English), pheasant, grouse, prairie chicken, ptarmigan, snipe, plover, duck, swan.

Exceptions: Heads, horns, and skins of big game lawfully killed by the shipper may be shipped under his hunting license. Any animal or bird, dead or alive, may be exported for scientific, zoological, or government purposes under permit by provincial secretary.

Manitoba:

Deer, elk, moose, caribou, antelope, quail, grouse, partridge, prairie chicken, pheasant, plover, snipe, sandpiper, woodcock, duck.

Exception: Minister of agriculture and immigration may issue permit to export heads and skins of 2 of each species of game animals, and any game birds, except grouse, prairie chicken, and partridge, but not more than 100 geese and swans, or 50 ducks. (No export of ducks permitted before October 1.)

New Brunswick:[a]

Deer, moose, caribou, or any portion thereof; partridge, pheasant, woodcock, snipe, wood duck, dusky (black) duck, teal, goose, brant.

Exception: Surveyor-general may issue special license to export game alive or dead.

Newfoundland:

Caribou (antlers, heads, or skins), or partridge, willow or other grouse for sale.

Exceptions: Minister of marine and fisheries may issue special licenses to export game for breeding or scientific purposes. Nonresident may export 3 stag caribou under hunting license and export permit (fee, 50 cents); resident may export antlers, head, or skin of caribou under export permit; but not, in either case, for sale.

Nova Scotia:

All game protected by the Province, viz: Red deer, American elk, moose, moose skin, caribou, caribou skin, hare, rabbit, quail, Canada grouse (spruce partridge), ruffed grouse (birch partridge), pheasant, black cock, capercailzie, ptarmigan, sharp-tailed grouse, woodcock, snipe, plover, curlew, yellowlegs, beach birds, all waders and sandpipers, blue-winged duck, teal, wood duck, American scoter (black coot), surf scoter (sea coot), American eider, king eider, harlequin duck, old squaw, whistler, American scaup duck, lesser scaup duck (bluebill), white-winged coot, American widgeon, gannet, goose, brant, heron, bittern, loon, gull, least tern, stormy petrel.

Exceptions: Holder of general license may take with him, out of Province, one moose lawfully shot by himself; and mounted heads and dressed skins or live mammals or birds for propagation may be exported under permit from Provincial secretary.

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[a] Except in the case of partridge the prohibition applies only to common carriers.

Ontario:

All wild game animals and birds.

Exceptions: Two deer, 1 bull moose, 1 bull caribou, and 100 ducks may be exported under nonresident hunting license, if shipping coupon and, if required, affidavit of lawful killing, be attached and contents of packages be open to view. Lawfully imported game and deer, moose, elk, or caribou held by private ownership may be exported.

Prince Edward Island:

All game except geese and brant.

Exception: Nonresident licensee may carry out of Province 12 birds killed by himself.

Quebec:

Native deer, moose, caribou, or parts thereof, except under permit from Minister of colonization, mines, and fisheries (fee not to exceed $5) under tags attached to nonresident licenses, and not later than 15 days after close of season.

Saskatchewan:

Deer, elk, moose, caribou, buffalo, sheep, goat, antelope, grouse, prairie chicken, ptarmigan, pheasant, snipe, sandpiper, plover, curlew, shore bird, rail, coot, crane, duck, goose, swan.

Exceptions: Commissioner of agriculture may grant permits to export for propagation for public parks and zoological gardens or scientific purposes 1 pair of each species of big game and game birds upon payment of $5, or a specified number on application of another Province or State. The holder of a general nonresident license may take with him out of the Province as trophies heads, skins, and hoofs of big game which he has legally killed.

Canada also has a general law prohibiting export of deer (except those raised on private preserves), wild turkeys, quail, partridges, prairie fowl, and woodcock, and permitting each nonresident to export two deer in a year at certain ports within fifteen days after the close of the open season, under permit of the collector of customs of the port from which export is made. The ports of export are: Halifax and Yarmouth, Nova Scotia; Macadam Junction, New Brunswick; Quebec, Montreal, and Ottawa, Quebec; Kingston, Niagara Falls, Fort Erie, Windsor, Sault Ste. Marie, and Port Arthur, Ontario; and such others as the minister of customs may designate.

Those who visit Canada to hunt, camp, etc., must deposit with the customs officer at the port of entry an amount equal to the duty (30 per cent of appraised value) on their guns, canoes, tents, cooking utensils, and kodaks. If these articles are taken out within six months at the same port, the deposit will be returned. But members of shooting or fishing clubs that own preserves in Canada and have filed a guaranty with the Canadian commissioner of customs may present club membership certificates in lieu of making the deposit. They must, however, pay duty on all ammunition and provisions.

SALE.

Legislation restricting the sale of game is passing through a transition stage. Some States prohibit the sale of game throughout the year, others only in close season, and between these extremes may be found all gradations and exceptions, such as restrictions prohibiting sale of game outside the State or for export, and exemptions allowing sale for a few days in the close season. The difficulty of tabulating

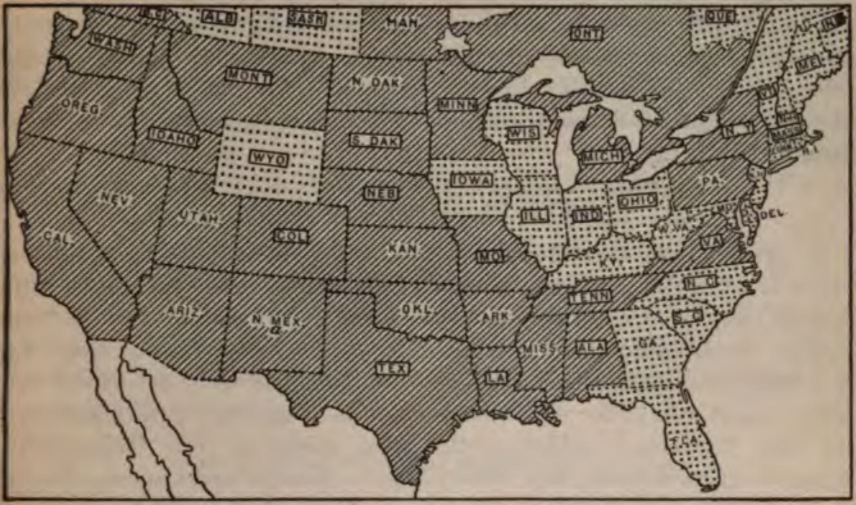

FIG. 3.—States and Provinces which prohibit export of game.

Ruled areas indicate States which prohibit export of any game; dotted areas, States which prohibit export of certain kinds of game. Inclosed names indicate special exceptions permitting nonresident hunters to take out a limited amount of game. The letter *a* indicates prohibition of export for sale only. Alaska and Nova Scotia prohibit export of any game; Newfoundland and Prince Edward Island export of certain species. All permit nonresident licensees to take out game. (For details, see pp. 30–36.)

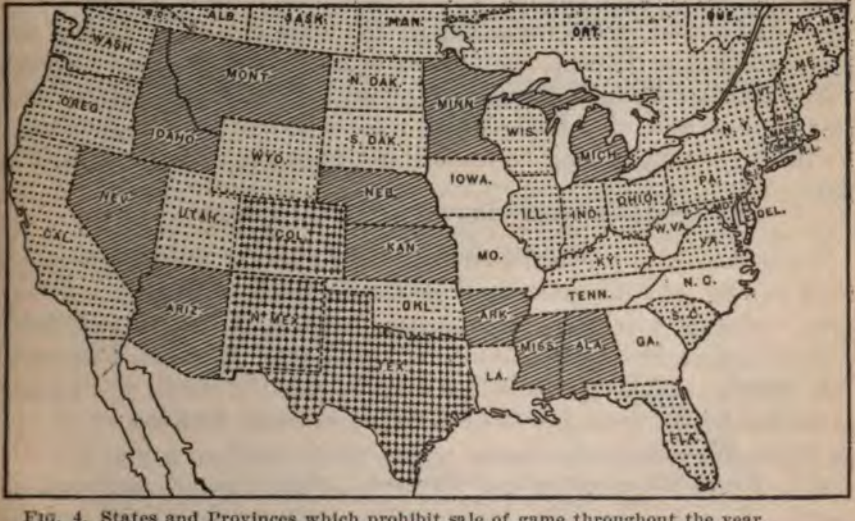

FIG. 4. States and Provinces which prohibit sale of game throughout the year.

Ruled areas indicate States prohibiting sale (resale in Nevada) of all protected game; crossed areas, States prohibiting sale of all protected game taken in the State, and dotted areas, States prohibiting sale (resale in Delaware) of certain game. Newfoundland and Nova Scotia prohibit sale of certain game. (For details, see pp. 39–42.)

MAPS SHOWING RESTRICTIONS ON EXPORT AND SALE IN 1908.

such regulations is increased by the fact that in addition to the special sale laws, close seasons, and provisions regarding possession must be taken into consideration. In consulting the following summary, therefore, it will be necessary to bear in mind three different classes of restrictions: "Sale in close season," "Sale in open season," and "Sale prohibited all the year."

SALE IN CLOSE SEASON.

In general, the sale of game is prohibited during the close season, but a brief additional open period is sometimes provided in order to permit dealers to close out stock on hand at the end of the hunting season. In Colorado, Illinois, Iowa, Nebraska, New York, Tennessee, and British Columbia the sale season includes the open season and the following five days for all or certain kinds of game. An extension of ten days for sale is added to the open season in New Brunswick; fifteen days in Alaska, New Jersey, Pennsylvania, and Quebec; thirty days (for imported ruffed grouse) in Pennsylvania; sixty days in Yukon; three months (for goose and brant) in New Brunswick; and until the following 1st of January in Ontario.

SALE IN OPEN SEASON.

In order to counteract a tendency on the part of market hunters to anticipate the opening of the season, the sale of certain game is sometimes prohibited at the beginning of the open season, as during the first two days in Illinois, the first three in Nova Scotia and Quebec, and the first month in British Columbia. Washington permits the sale of snipe and wild fowl (which may be killed from September 1 to March 1) only during November and then not more than 25 in a day.

SALE PROHIBITED ALL THE YEAR.

Forty-four States and Territories[a] and most of the Provinces of Canada now prohibit sale of all or certain kinds of game at all seasons. (See fig. 4, p. 37.) In Alabama, Arizona, Arkansas, Colorado, Idaho, Kansas, Michigan, Minnesota, Mississippi, Montana, Nebraska, New Mexico, and Texas the sale, and in Nevada the resale, of all game protected by the State law is prohibited; in South Dakota, of all big game; in Wisconsin, of all game except rabbits and squirrels; in California, Utah, Washington, and Manitoba, of all big game and upland game. In a few instances prohibitions against the sale of certain game are so general as to afford protection over a considerable area in adjoining States. Thus, ruffed grouse can not be sold in any State or Province along the Canadian border except Vermont, New York, Pennsylvania, Ohio, New Brunswick, and Quebec, nor in the States of Massachusetts, Rhode Island, Connecticut, Arkansas, Kansas, Nebraska, or Wisconsin. Practically every State in which prairie chickens occur now prohibits their sale or export. Hence exposure of these birds for sale in any State where they do not occur, as in any city east of Indianapolis, is strong indication of violation of law.

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[a] Omitting Tennessee and North Carolina, which prohibit sale in only a few of their counties, and Alaska, which prohibits sale of only heads, skins, and trophies.

The following table shows the kinds of game, sale of which is prohibited throughout the year. The sale of all other game is so generally prohibited during the close season as to render a detailed enumeration unnecessary, but when an extension of a few days is added to the open season or a special season is provided for either possession or sale, attention is called to this exemption under the heading "Permitted."

Sale of Game Prohibited throughout the Year.

Alabama:

All game protected by the State.

Alaska:

Heads, hides, and skins of all protected game.

Permitted: Carcasses of all game may be sold during the open season and 15 days thereafter.

Arizona:

Deer, elk, antelope, sheep, goat (or meat, hide, head, or horns of said animals), quail, bobwhite, partridge, grouse, pheasant, wild turkey, dove, snipe, rail, duck, goose, brant.

Arkansas:

All "game, wild fowl, or birds whatsoever," except deer raised in captivity, bears, rabbits, opossums, raccoons, and squirrels.[a]

California:

Deer meat and hides of female deer, or those from which evidence of sex has been removed, quail, partridge, grouse, pheasant, sage hen, dove, ibis, snipe, plover, rail, or shore birds.

Colorado:

All game taken in the State.

Permitted: Domestic game may be sold by hotels, restaurants, etc., during the open season and five days thereafter, or during the limits of a storage permit. Imported game (under license) and game taken from licensed private parks and lakes may be sold at any time if accompanied by an invoice.

Connecticut:

Quail, ruffed grouse, woodcock, until October 1, 1911.

Delaware:

Quail, partridge, pheasant; buying for sale prohibited.

Florida:

Deer, deer hides, quail or partridge, wild turkey.

Idaho:

All game protected by the State.

Illinois:

Deer, squirrel (gray, red, fox, black), quail, Mexican blue quail, California mountain quail, California valley quail, ruffed grouse (pheasant), pinnated grouse (prairie chicken), pheasant (English ringneck, Chinese ringneck, green (Japanese), copper (Soemmerring), tropogan [tragopan], silver, golden, Reeves, Elliot, Hungarian, Swinhoe, Amherst, melanotte, impeyan, argus); partridge (Hungarian, black Indian, caccabis, chukar), sand grouse; capercailzie, heath grouse (black grouse), wild turkey, duck, goose, brant, coot, rail.

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[a] Squirrels killed in Ouachita and Union counties can not be sold, and no squirrels can be sold in Craighead, Dallas, and Lafayette counties.

Illinois—Continued.

Permitted: Deer bred in inclosures for market may be sold at any time; cock pheasants may be sold by breeders (under permit of State game commissioner) in November and December, doves, woodcock, snipe, plover, coot, and rail may be sold from the third day of the open season to the fifth day of the close season; and game imported from other States from October 1 to February 1.

Indiana:

Quail.

Iowa:

Permitted: All game may be sold during the open season and five days thereafter.

Kansas:

Red squirrel, quail, partridge, grouse, pinnated grouse (prairie chicken), pheasant, dove, plover, duck, goose, brant (buying also prohibited).

Kentucky:

Quail, partridge, grouse, pheasant, wild turkey, killed in the State.

Louisiana:

Permitted: Game birds may be sold during open season, but not later than March 1.

Maine:

Deer, moose, or game birds for export. Ruffed grouse, woodcock, all protected ducks, for any purpose.

Permitted: Deer may be sold by local dealers under license.

Maryland:

Anne Arundel—All game except squirrel, rabbit, and raccoon.

Baltimore—Partridge, pheasant, woodcock for export.

Calvert—Rabbit, quail, woodcock for export for sale.

Frederick—Squirrel, partridge, pheasant, woodcock, taken in county.

Montgomery—Partridge, pheasant, wild turkey, for export.

Somerset—Rabbit, quail or partridge, woodcock, dead or alive, for any other purpose than as food within the county or for propagation; or any game for export.

Washington—Deer, squirrel, rabbit, partridge, pheasant, wild turkey, woodcock.

Wicomico—Quail or partridge for export (from Wicomico and Worcester counties considered as one territory).

Worcester—Rabbit, quail, woodcock (except to consumer).

Permitted: Baltimore City—Ruffed grouse may be sold October 1–December 25.

Massachusetts:

Deer, gray squirrel, and quail taken in the State, ruffed grouse, heath hen, prairie chicken, sharp-tailed grouse, woodcock, and wood duck.

Permitted: Dealers or persons in the cold-storage business may sell imported quail lawfully obtained during November and December, and may sell at any time hares or rabbits lawfully secured. Live quail for propagation may be sold under permit.

Michigan:

All game protected by the State.

Minnesota:

All game protected by the State.

Mississippi:

All game protected by the State.

Missouri:

All game protected by the State.

Permitted: Game lawfully secured may be sold in county of capture. Imported game may be sold during open season.

Montana:

All game protected by the State.

Nebraska:

All game protected by the State.

Nevada:

Resale of all game.

New Hampshire:

Ruffed grouse or partridge, woodcock.

New Jersey:

Deer taken in the State until November 10, 1909.

Permitted: All other game may be sold during the open season and, if native game, fifteen days thereafter.

New Mexico:

Deer, elk, antelope, sheep, native or crested and bobwhite quail, partridge, grouse, pheasant, ptarmigan, wild turkey, turtle dove, wild pigeon, killed in the Territory.

ew York:

Quail, grouse, and woodcock taken in the State.

Permitted: Deer may be sold from September 16 to November 6. Moose, elk, caribou, and antelope imported or killed in a private park by the owner during the open season for deer may be sold at any time; and imported quail, grouse, and woodcock under bond during the open season and until January 3. Pheasants bred or liberated in Dutchess and Suffolk counties may be possessed at any season in Greater New York for consumption, but not for sale. Ducks, geese, brant, and swans may be possessed during the open season and until March 1. On Long Island ducks, geese, and swans may be possessed from October 1 to March 1, and brant until May 1. Squirrels, hares, and rabbits, quail, grouse, and woodcock lawfully taken on Long Island may be possessed in the city of New York during the open season in the State at large.

orth Dakota:

Deer, ruffed grouse, pinnated grouse, prairie chicken, sharp-tailed grouse, woodcock.

hio:

Squirrel, quail, ruffed grouse, introduced pheasants, dove, woodcock, snipe, plover, shore bird, rail, duck, goose, swan, coot (mud hen).

klahoma:

Deer, antelope, quail, grouse, prairie chicken, wild turkey, dove.

regon:

Deer, elk, moose, sheep, silver-gray squirrel, quail, bobwhite quail, partridge, grouse, ruffed grouse, capercailzie, moor hen, pheasant (silver, golden, copper, green Japanese, Reeves, and ringneck), wild turkey, woodcock, upland plover, rail, duck, swan.

Permitted: Five deerskins, properly tagged, may be sold in a season by the hunter who originally secured them. Tags not issued after first five days of close season.

ennsylvania:

Deer, quail, partridge, grouse, pheasant, taken in the State; wild turkey and woodcock (wherever taken).

Permitted: Squirrel, rabbit or hare, bear, dove, reedbird, blackbird, upland plover, Wilson or jack snipe, sandpiper, tatler, curlew, or any other shore bird, rail, coot or mud hen, duck, goose, brant, and swan taken in the State may be sold during the open season and fifteen days thereafter; ruffed grouse taken outside of the State may be sold during the open season and thirty days thereafter.

hode Island:

Quail, ruffed grouse, pheasant, woodcock.

outh Carolina:

Quail or partridge taken in the State, until Feb. 20, 1912; Mongolian or other pheasant, wild turkey, and woodcock, taken in the State, until March 1, 1911.

outh Dakota:

Deer, elk, buffalo, sheep.

Permitted: Skins, heads, and antlers of animals lawfully killed may be sold at any time.

ennessee:

Dyer County—Wild turkey.

Permitted: All game may be sold in the State during the open season and five days thereafter.

exas:

All game animals, hides and horns, wild birds, and wild fowl found in the State.

tah:

Deer, elk, antelope, sheep, quail, partridge, grouse, prairie chicken, sage hen, pheasant, Mongolian, Chinese, and English pheasant, dove.

Permitted: 25 in all of shorebirds and waterfowl may be sold in a day to private parties.

ermont:

Quail, ruffed grouse, pheasant or English partridge, plover, English snipe, woodcock, duck, goose, except for consumption as food in the State.[a]

irginia:

Quail, partridge, grouse, pheasant, woodcock, English or Mongolian pheasant (except for propagation) until January 1, 1900.

Carroll, Grayson, Greenesville, Patrick, Sussex counties—Quail or partridge taken in county.

Clarke County—Quail, rabbit, squirrel, pheasant, wild turkey (outside of county).

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[a] Game from private game preserves stocked at owner's expense may be sold at any time.

Virginia—Continued.

Frederick, Shenandoah counties—Quail, ruffed grouse, wild turkey, woodcock (prohibition applies only to nonresidents of Virginia).

Page County—Quail (for export).

Washington:

Deer, elk, moose, caribou, sheep, goat, quail, partridge, grouse, prairie chicken, sage hen, ptarmigan, pheasant, Chinese or Mongolian pheasant, sand-hill crane, plover, rail, swan, and all other game birds except ducks, geese, and brant.

Permitted: Ducks, geese, and brant may be sold during November, but only 25 in a day.

Wisconsin:

Venison, quail, partridge, grouse, prairie chicken, pheasant, Mongolian, Chinese, or English pheasant, snipe, plover, woodcock, duck, goose, brant, or other aquatic bird.

Wyoming:

Deer, elk, moose, antelope, sheep, or skins, heads, antlers, or teeth thereof.

Permitted: Sale of 1 hide, 1 scalp, and 1 head of any big game, except moose, and 1 pair of elk tusks, on affidavit that they were taken from animals lawfully killed.

Alberta:

All game.

Permitted: The flesh of big game and game birds may be sold at any time under $10 license. Heads of big game before being sold must be stamped by minister of agriculture at fees of $5 for elk, caribou, moose, and sheep, and $2 for deer, antelope, and goat.

British Columbia:

Elk, quail, grouse, ptarmigan, prairie chicken, English partridge, pheasant, swan, female and young of deer, moose, caribou, or sheep, heads of moose, caribou, and sheep; also male deer on Vancouver Island.

Permitted: Male deer after September 1; male moose, caribou, sheep, goats, and hares after October 1; and snipe, plover, and ducks may be sold during the open season and five days thereafter.

Manitoba:

Deer, elk, moose, caribou, antelope (except heads and hides), quail, grouse, pheasant, partridge, prairie chicken, woodcock, plover, snipe, sandpiper.

Permitted: Possession of grouse, prairie chickens, and partridges allowed for forty-five days, and of ducks for three months, after close of hunting season.

New Brunswick:

Permitted: Geese and brant may be sold during the open season and until March 1, and all other game during the open season and (under license from game warden) ten days thereafter.

Newfoundland:

Capercailzie, black game.

Permitted: Caribou may be sold from August 1 to January 1.

Nova Scotia:

Deer, caribou to 1912, pheasant, blackcock, capercailzie, Canada grouse (spruce partridge), chukar partridge.

Permitted: Moose may be sold from October 1 to December 10. Any game bird other than those above mentioned during the open season with the exception of the first three days.

Ontario:

Quail, partridge, woodcock, snipe, subject to regulations of Lieutenant-governor in council.

Permitted: All other native game may be sold during the open season[a] by the person killing it and by dealers during open season and until the following January 1 under license. Imported game may be sold under special regulations and licenses.

Quebec:[b]

Birch or swamp partridge, woodcock, until October 1, 1910.

Permitted: All other game may be sold during the open season and fifteen days after the close thereof. Hotels, restaurants, and clubs may serve, under license, all game lawfully taken, except birch or swamp partridge and woodcock. Skins and heads of animals lawfully taken and animals kept alive may be sold.

Saskatchewan:

Sheep, goat, or prairie chicken, grouse, pheasant, ptarmigan, or other member of the Gallinæ, unless captured by the owner.

Yukon:

Permitted: Deer, elk, moose, caribou, bison, musk oxen, sheep, and goats may be sold during the open season and sixty days thereafter.

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[a] Seasons depend on regulations of game commission.

[b] *Lieutenant-governor in council may prohibit sale of any game for 3 years or less or prolong any existing* period of prohibition for 3 years or less.

LIMITS.

Laws limiting the amount of game which can be killed in a day or a season are of comparatively recent origin. One of the first statutes of the kind was that passed in Iowa in 1878 (ch. 156, sec. 3), limiting the killing or possession of prairie chickens, snipe, woodcock, quail, and ruffed grouse to 25 in a day.[a] Maine in 1883 (ch. 185, sec. 1) limited the number of big game which an individual might kill in a season to 1 moose, 2 caribou, and 3 deer; and New York in 1886 (ch. 194, sec. 1), likewise limited the number of deer to 3. In the last thirty years laws of this kind have been generally adopted and are now in force in all except 9 States. In spite of the objection often urged against such statutes—that they are impossible of enforcement and easily evaded—experience has shown them to constitute one of the most effective features of modern game legislation. They have been tested in the courts and upheld by the supreme courts of several States, notably those of Maine and Wisconsin.[b]

When restrictions on limits are extended to possession and shipment as well as killing, and the total amount of game allowed a party made less than the quantity allowed the individual members of the party, little difficulty is experienced in enforcing the statute. Moreover, among law-abiding sportsmen the incentive to make large bags is removed when the act is declared illegal. The bag-limit law has entirely changed the character of the hunting in some States, where, instead of attempting to kill the largest possible number of birds, the effort of the sportsman is now directed toward obtaining the limit in the shortest possible time.

In recent years bag limits have been materially reduced, and only a few States now allow more than 2 deer a season or 1 head of other big game, while the usual limits per day in the case of birds are 10 grouse or woodcock, 15 quail, and 25 waterfowl. In Canada, where the country is not so closely settled, bag limits on birds are fewer and those on big game more liberal than in the United States.

Limits Fixed by Law for the Capture of Game.

Alabama:
One deer, 2 turkeys, 25 of each other kind of birds a day.

Alaska:
Two moose, 3 each of caribou, sheep, and brown bears a season; 25 grouse, ptarmigan, shore birds or waterfowl a day.

Arizona:
Three deer a season, 25 quail a day.

Arkansas:
No limits, except in Desha County, in which the limit is 4 deer a season, or an average of 1 deer to each member of a hunting party.

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[a] This statute was, however, preceded by one enacted in 1874 limiting the shipment of game birds to one dozen a day, provided the birds were not shipped for sale (ch. 69, sec. 1).

[b] See Allen v. Leighton, 32 Atl., 877 (Maine, 1895); State v. Nergaard, 102 N. W., 899 (Wisconsin, 1905).

California:

Two deer a season; 25 each of quail, partridges, snipe, plover, curlew, shore birds, rail, ibises, and doves, and 35 ducks a day.

Colorado:

One deer a season; 25 ducks a day, 50 in possession at once; 25 other birds a day, 50 in possession at once.

Connecticut:

Five ruffed grouse a day, 36 a year; 35 rail, 50 each of plover, snipe, shore birds a day.

Delaware:

No limits.

District of Columbia:

No limits.

Florida:

Five deer, 5 turkeys a year; 20 quail, 2 turkeys by individual or 40 quail, 4 turkeys by party a day.

Georgia:

Forty doves a day.

Idaho:

Two deer, 1 ibex, 1 goat, 1 sheep, 1 elk a season; 18 quail, 12 each of sage hens, partridges, pheasants, grouse, prairie chickens, 24 ducks, 3 geese a day.

Illinois:

Fifteen squirrels; 20 rail, ducks, geese, brant, coots, or other waterfowl and 15 other birds a day.

Indiana:

Fifteen quail; 15 ducks or other waterfowl a day; 45 birds in possession as result of 3 or more days' consecutive hunting.

Iowa:

Twenty-five each of quail, prairie chickens, ruffed grouse or pheasants, woodcock, wild turkeys, ducks, geese, and brant a day.

Kansas:

Twenty each of quail, plover, duck; 15 each of grouse, prairie chickens; 10 each of geese, and brant a day.

Kentucky:

No limits.

Louisiana:

Two deer a day, 6 a season; 25 birds a day.

Maine:

One moose, 2 deer a season (except in Cumberland, Knox, Kennebec, Lincoln, Sagadahoc, Waldo, and York counties, limit 1, and in lumber camps, limit 6); 15 each of ruffed grouse, woodcock, plover, snipe, ducks, and 70 sandpipers a day.

Maryland:

No limits.

Massachusetts:

No limits.

Michigan:

Two deer a year; 12 each of quail, grouse, spruce hens a day, 50 in possession at a time; 25 ducks, waterfowl, snipe, plover, woodcock a day, 75 in possession at a time.

Minnesota:

One deer (nonresident), 2 deer (resident), 1 moose a season, 15 birds a day.

Mississippi:

One deer a day, 5 in a season; 20 each of quail, wild turkeys, plover, tatlers, chorooks, grosbecs, coots, poule d'eau, rails, ducks, swan, geese, brant a day.

Missouri:

One deer, 2 turkeys, 25 of any other species a day; or 2 deer, 4 turkeys, 50 of any other species in possession at a time.

Montana:

Three deer, 1 elk, 1 antelope, 1 goat, 1 sheep a season; 10 each of grouse, prairie chickens, fool hens, pheasants, sage hens, partridges, turtle doves a day.

Nebraska:

Ten geese or brant, 25 other birds (in September only 10 prairie chickens or grouse) a day; 10 geese or brant, 50 other birds in possession at a time.

Nevada:

Three deer, 3 antelope a season; 20 quail, 20 ducks, 20 sage hens, 6 grouse, 5 plover, and 15 snipe a day.

New Hampshire:

Two deer a season.

New Jersey:
Thirty marsh hens a day.

New Mexico:
One deer a season.

New York:
Two deer, 36 quail, 36 woodcock, 20 grouse a season; 6 quail, 6 woodcock, 4 grouse a day.

North Carolina:
Buncombe County, 25 quail or partridges, pheasants, grouse, wild turkeys or doves; Cabarrus County, 15 quail or partridges; Madison County, 25 birds; Transylvania County, 10 squirrels, 20 quail or partridges a day.

North Dakota:
Five deer a season; 25 birds a day.

Ohio:
Twelve each of quail, doves, woodcock, snipe, plover, rail, shore birds, geese; 25 ducks a day.

Oklahoma:
No limits.

Oregon:
Five deer a season; 10 each of quail (east of Cascades, 6 a day, 12 a week), grouse, prairie chickens, ringneck pheasants a day; 50 ducks a week.

Pennsylvania:
One deer a season, 6 squirrels a day; 5 each of ruffed grouse, introduced pheasants, 10 woodcock a day, 20 a week, 50 a season; 10 quail a day, 40 a week, 75 a season; 1 wild turkey a day, 4 a season.

Rhode Island:
No limits.

South Carolina:
No limits.

South Dakota:
Two deer, 1 elk, 1 buffalo, 1 sheep a year; 15 birds a day.

Tennessee:
Fifty ducks; 30 of all other birds in aggregate a day.

Texas:
Three deer a season; 25 birds a day (three wild turkeys December to February).

Utah:
Two deer a season (residents only), 12 quail a day (in Davis, Salt Lake, Utah, and Weber counties); 8 each of partridges, pheasants, prairie chickens, sage hens, grouse, doves, and 25 in all of snipe, shore birds, ducks, geese, brant, swans a day.

Vermont:
One deer and 35 ruffed grouse or woodcock a season; 5 each of gray squirrels, quail, ruffed grouse, pheasants, woodcock, plover, English snipe, geese, and 20 ducks a day.

Virginia:
No limits.

Washington:
Four deer, 1 moose, 1 antelope, 1 caribou, 2 sheep, 2 goats a season; 10 each of partridges, Chinese pheasants, ptarmigan, grouse, prairie chickens, sage hens; 15 quail; 25 each of plover, rail, cranes, snipe, ducks, or other waterfowl a day.

West Virginia:
Two deer a season; 12 quail a day.

Wisconsin:
One deer a year for nonresidents, 2 for residents; 10 grouse, prairie chickens, woodcock, 10 geese or brant, 15 partridges, 25 ducks, plover, snipe, coots, rail a day.

Wyoming:
Two deer, 1 elk, 1 antelope, 1 sheep a season; 12 birds a day.

Alberta:
One deer, 1 moose, 1 caribou, 2 antelope a season; 20 grouse, partridges, pheasants, prairie chickens, ptarmigan a day, or 200 a season.

British Columbia:
Five deer, 2 elk, 2 moose, 5 caribou, 5 goats, 3 sheep, 250 ducks and 250 snipe a season.

Manitoba:
One deer, 1 elk, 1 moose, 1 caribou, 1 antelope a season; 20 in all of grouse, partridges, prairie chickens a day, 100 a season; 50 ducks a day in September.

New Brunswick:
Two deer, 1 moose, 1 caribou a season.

Newfoundland:
Three caribou a season.
Nova Scotia:
One moose a season; 5 ruffed grouse, 15 woodcock a day.
Ontario:
Two deer, 1 moose, 1 caribou a season. Two or more persons hunting together under license may kill an average of 2 deer each.
Prince Edward Island:
No limits.
Quebec:
Zone 1: 2 deer, 1 moose, 2 caribou a season.
Zone 2: 2 deer, 1 moose, 4 caribou a season.
Saskatchewan:
Two deer, 2 elk, 2 moose, 2 caribou, 2 antelope a season; 10 grouse, partridges, pheasants, prairie chickens, ptarmigan a day, or 100 a season.
Yukon:
Six caribou or deer, 2 moose, 2 elk, 2 sheep, 2 goats, 2 musk oxen a season.

LICENSES FOR HUNTING AND SHIPPING GAME.

In Arkansas nonresidents are not permitted to hunt,[a] except on their own premises, and in 43 States and Territories[b] and throughout Canada licenses must be secured before nonresidents can hunt any or certain kinds of game (see fig. 2, p. 4). In 22 States and 5 Canadian Provinces a like restriction is imposed on residents, but the fees are usually very much smaller, and often are merely nominal (see fig. 1). The fees for nonresident licenses for both big and small game range from $10 in a number of States to $50 in Alaska, Wyoming, New Brunswick, and Newfoundland, and $100 in British Columbia and Saskatchewan; those for resident licenses from 75 cents in North Dakota to $5 in Washington, and $7 ($5 for moose and caribou and $2 for deer) in Ontario.

A new kind of hunting license, often known as the "alien" license, has recently been adopted by several States to restrict hunting by persons who are not citizens of the country. Thus Alabama, Florida, New Hampshire, New Jersey, New York, Pennsylvania, Louisiana, South Carolina, Texas, Utah, and Wyoming provide that all hunters who are unnaturalized residents of the State must obtain the same license required of nonresidents; Massachusetts has a special $15 license for resident aliens, Connecticut and Maine a $15, and Washington a $50 license for nonresident aliens, California a $25 license, Alaska a $100 license, and Manitoba a $100 license for all aliens.

Licenses are generally issued only for the open season, and thus expire at fixed dates. Some are necessarily very brief in duration. Michigan issues a $25 nonresident deer license good only for twenty days in November; Vermont, a $15 nonresident deer license good only for the last six consecutive week days of October. In a few instances licenses are issued at reduced rates for a week or for a few days. Of this character are the nonresident bird license, good for one week, issued by British Columbia; the guest licenses, good for five days, issued by Alberta and Saskatchewan; and the daily licenses issued for hunting birds in Colorado and any game in Lafayette and Sumter counties, Fla.

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[a] Except in Desha County where they are permitted to hunt as guests of licensed residents.

[b] Not including Georgia, in which a license must be secured to hunt for market.

Eleven States issue licenses good only in the county named therein—Alabama, Colorado, Florida, Georgia (market hunting), Iowa, Maryland, Mississippi, Missouri, South Carolina, South Dakota, and Washington—with fees ranging from $1 for residents of Alabama and Washington, to $50 for residents hunting wild fowl for market in South Carolina.

Twenty-eight States and Territories and 10 Canadian Provinces which prohibit export of all or certain of their game allow a limited amount of such game to be taken or shipped out by nonresidents under hunting licenses, and 3—Alaska, Maine, and Michigan—provide for further shipment under special export permits; while 15 States and Territories make no exception to their nonexport laws in favor of nonresident licensees.

Nonresident landowners or taxpayers are not required to pay the usual fee in California, Kansas, Maryland (most counties),[a] Massachusetts, Michigan, Mississippi, New Hampshire, New Jersey (alien), North Dakota, Oregon, South Carolina, Tennessee, Nova Scotia, Vermont, West Virginia, and Prince Edward Island. But to secure this exemption in Massachusetts and New Hampshire the nonresident hunter must own land to the value of $500 and $1,000, respectively; in Tennessee, Nova Scotia, and Prince Edward Island he must pay a tax of at least $100, $30, or $25 per annum, respectively, and in North Dakota must own or cultivate a quarter section of land. Similar exemptions are made in the case of resident landowners (and, in some instances, their tenants hunting on their land) in Alabama, California, Colorado, Connecticut, Illinois, Indiana, Kansas, Louisiana, Montana, New York, North Dakota, and Oregon, and no license is required of those hunting within their own county in Minnesota, Missouri, Nebraska, or Nova Scotia. Special exemptions are made in favor of nonresident members of fish and game clubs by Kansas, Massachusetts, Rhode Island, and Quebec. In Virginia no license is required of bona fide guests of residents, and in Ontario no fee is charged for a guest license.

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[a] All the counties of Maryland allow nonresidents to hunt without license on invitation of landowners, except Allegany, Caroline, Dorchester, Garrett, Kent, Somerset, Talbot, and Worcester. (Dorchester grants the privilege if the nonresident be a relative of his host, and Wicomico if he be accompanied by a resident while hunting.)

In Maine,[a] South Dakota, Wyoming, New Brunswick (on wild lands), and Nova Scotia nonresidents are not permitted to hunt big game unless accompanied by qualified guides, and in Alaska, Colorado, Maine, Montana, Wyoming, Alberta, New Brunswick, Newfoundland, Nova Scotia, and Ontario guides are licensed. Maine, Alberta, and New Brunswick also license camp help. Nearly every State requires licensees to have their licenses in personal possession while hunting and to exhibit them on demand of any warden (in New Hampshire and New York of any person).[b]

Details in regard to hunting licenses are given in the following table. In every case the statement regarding the fee includes the amount charged for issuing the license by the county clerk or other officer.

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[a] On wild lands of the State, except from December 1 to 15.

[b] The following counties in North Carolina require hunters to obtain written permission for hunting on lands other than their own: Buncombe, Carteret (Morehead Township), Cherokee, Clay, Craven, Currituck, Davidson, Henderson, Hertford, Iredell, Jones, Madison, Martin, (Cross Roads, Goose Nest, Hamilton, and Poplar Point townships), Randolph (townships of Back Creek, Franklinsville [quail], and New Hope), Richmond (Mineral Springs and Wolfpit townships), Robeson, Rowan, Rutherford (Rutherford Township), Transylvania, Union, Wayne, and Yadkin.

State.	Kind of license.	Fee.	By whom issued.	Details of license.	Export limit.
Alabama	Nonresident	$15.00	Probate judge of the county.	Expires Dec. 31	Nonresident licensee may carry out of State or have carried to him game lawfully killed by him.
	Alien	15.00	....do	....do	
	Resident	3.00	....do	State license; required to hunt outside of county of residence, except on lands owned or leased by hunter. Expires Dec. 31.	
	Resident	1.00	....do	County license; except on lands owned or leased by licensee. Expires Dec. 31.	
Alaska	Nonresident	50.00	Governor	American citizen. Expires Dec. 31.	2 moose, north of lat. 62°, 4 deer, 3 caribou, 3 sheep, 3 goats, and 3 brown bears.
	Alien	100.00	....do	Nonresident. Expires Dec. 31	
	Guide		....do	American citizen or native of Alaska. Fee fixed by governor.	
	Shipping (resident)[a]	40.00	....do	For export of heads or trophies from Alaska by resident.	1 moose, north of lat. 62°, 4 deer, 2 each of caribou, sheep, goats, and brown bears.
	....do	10.00	....do	....do	1 caribou or sheep.
	....do	5.00	....do	....do	1 deer, goat, or brown bear.
	Shipping (special)[a]	150.00	....do	For export of moose from southern Alaska by any person.	1 moose, south of lat. 62°.
Arizona	Nonresident	10.00	Fish and game commissioner or county recorder.	Deer only	No export.
Arkansas				Nonresidents not permitted to hunt[b]	Do.
California	Nonresident	10.00	Board of fish commissioners, county clerks.	Expires not later than June 30. Landowners hunting on their own lands exempt.	Do.
	Alien	25.00	....do	....do	
	Resident	1.00	....do	....do	
Colorado	Nonresident	25.00	Commissioner of game	Expires Dec. 31	Permit from commissioner required.
	....do	2.00	....do	County license for birds, $2 first day; each subsequent day $1. Expires Dec. 31.	
	Resident	1.00	Commissioner of game or county clerk.	Expires Dec. 31. Owners of farms or grazing lands hunting on their premises exempt.	
	Guide	5.00	Commissioner of game	Expires Dec. 31. Must have in addition a State license.	
Connecticut[c]	Nonresident	10.25	Town, city, or borough clerk.	Good for 1 year from date of issue	No quail, ruffed grouse, or woodcock.
	Alien	15.25	....do	....do	
	Resident	1.10	....do	....do	

[a] Not more than one general ($40) license and 2 special ($150) moose licenses issued to one person in one year. Each shipper must file with customs office at port of shipment an affidavit that he has not violated the game law, that the trophy to be shipped has not been bought or purchased, has not been sold, and is not shipped for purpose of sale; but he is the owner of the trophy, and, in case of moose, whether the animal from which it was taken was killed north or south of latitude 62°.

[b] But see State *v.* Mallory, 83 S. W. 955, deciding that nonresidents may hunt on their own land. In Desha County nonresidents may hunt when host has $1.50 resident license.

[c] No license is required of a bona fide resident of Connecticut, or his lineal descendants, hunting on land occupied by him and used for agricultural purposes.

Details of hunting licenses and export regulations—Continued.

State.	Kind of license.	Fee.	By whom issued.	Details of license.	Export limit.
Delaware	Nonresident	$5.00	Delaware Game Protective Association.	$2 for each subsequent year	No rabbit, quail, partridge, robin, woodcock, Wilson snipe.
Florida	Noncitizen	10.00	Clerk of circuit court	County license. Expires Mar. 1[a]	No deer, quail, or wild turkeys.
Georgia	Market hunting	25.00	Ordinary of county	County license; permits killing for sale. Expires Dec. 31.	No quail.
Idaho	Nonresident	25.00	State warden, deputy probate judge, or justice of the peace.	Expires Jan. 31	2 deer, 1 ibex, 1 mountain goat, 1 mountain sheep, 1 elk. No birds.
	Nonresident	5.00	....do	Birds only. Expires Jan. 31	
	Resident	1.00	....do	Expires Jan. 31. Not required of women	
Illinois	Nonresident	15.50	City, village, or county clerk.	Expires June 1	50 birds of all kinds.
	Resident	1.00	....do	Expires June 1. Not required of owners and tenants of farms hunting on their lands.	
Indiana	Nonresident	15.50	Clerk of circuit court	Good for 1 year	15 birds of all kinds, or 45 in case of 3 or more days' consecutive hunting.
	Resident	1.00	Commissioner of fisheries and game, clerk of circuit court.	Good for 1 year. Not required of landowners hunting on their own lands, nor of their children or tenants, nor for hunting rabbits in township of residence.	
Iowa	Nonresident	10.50	County auditor	County license. Expires Jan. 1	25 of all kinds of game.
Kansas	Nonresident	15.00	Secretary of state	Expires June 30. Not required of owners of land and members of hunting club hunting on their own premises.	No export.
	Resident	1.00	County clerk	....do	
Kentucky	Nonresident		....do	Expires 1 year from date of issue. Same fee as resident of Kentucky is subject to in State of nonresident.	Do.
Louisiana	Nonresident	25.00	Tax collector	County license. Required of nonresidents and unnaturalized foreign-born residents. Good for season.	1 deer and 2 wild turkeys, 25 ducks, and 12 other birds, twice a season.
	Resident	1.00	....do	State license. Good for season. Not required of person hunting on his own land.	
Maine	Nonresident	15.00	Commissioners of inland fisheries and game.	All game during October, November, and December.	1 moose, 2 deer, 10 each of partridges, ducks, and woodcock.
	Nonresident	5.00	....do	Game that may be shot before Oct. 1. Licensee may procure moose and deer license by payment of $10 additional.	
	Alien	15.00	....do	Not required of aliens who have resided in State 2 years continuously prior to 1907 or pay taxes in State.	
	Camp keeper	5.00	....do		

	Nonresident	10.00	Commissioner of fisheries and game.	Expires Dec. 31. Not required of owners of real estate to value of $500.	6 birds of those whose export is otherwise prohibited.
	Resident [c]	1.00	City and town clerk	Not required of persons hunting on land which they own or on which they live.	
Michigan	Nonresident	25.00	County clerk	Deer. Good for season	1 deer under license and shipping permit.
	Nonresident	10.00	do	Small game only. Good for season. Not required of persons hunting on their own land.	
	Resident	1.50	do	Deer. Good for season	
	Export	10.00	State game and fish warden.		Nonresident landowner and member of a club maintaining a game preserve may export 50 ducks or migratory birds killed by him on said premises.
Minnesota	Nonresident	25.00	Board of game and fish commissioners.	Game animals. Expires Dec. 31	1 deer, 25 birds.
	Nonresident	10.00	do	Game birds. Expires Dec. 31	
	Resident	1.00	County auditor	Not required for county of residence. Expires Dec. 15.	
Mississippi	Nonresident	20.00	Sheriff	County license. Good for season. Landowners and their nonresident relatives and friends, hunting on their lands exempt.	No export.
Missouri	Nonresident	15.00	Circuit court clerk or license collector.	County license. Good for 1 year	1 deer, 2 turkeys, 25 quail, 25 ducks.
	Resident	1.00	do	Good for 1 year. Required for hunting in counties adjoining county or city of residence.	
	Resident	2.50	do	County license. Good for 1 year. Required for hunting in counties not adjoining residence.	
Montana	Nonresident	25.00	State game and fish warden or deputy.	Expires Dec. 31	Number permitted to be killed (see p. 44).
	Nonresident	10.00	do	Birds only. Expires Dec. 31	
	Resident [e]	1.00	State game and fish warden, or deputy, or justice of the peace.	Expires Dec. 31. Not required of landowners hunting on their own premises.	
	Guide	10.00	State game and fish warden.	Good for 1 year	
	Shipping	.50	do	Permits limited export in open season	

[a] Not applicable to counties having special game laws. Nonresidents of Lafayette and Sumter counties required to secure license of game warden and pay therefor $1 per day. Hernando County issues a $10 nonresident and a $1 resident license, both good for the season, and Clay County issues a $10 guide license; while no one is permitted to hunt in Taylor County who is between the ages of 18 and 60 and does not pay taxes or work on the roads in the county, nor in Wakulla County if between the ages of 21 and 55 and not a taxpayer of the State.

[b] County and local licenses are issued at the following rates, including clerk fees: Allegany, $10.50; Baltimore, $5.25; Calvert, $10.50; Caroline, $5; Carroll (upland game), $10.50; Cecil, $5.50; Charles (rabbit, quail, and woodcock), $20.50 (nonresidents not permitted to shoot waterfowl); Dorchester, $5; Frederick, $15.50; Garrett, $25.50; Harford, $10.50 (all game except waterfowl); Howard, $8; Kent, $15.50 (if invited by landowner, $5.50); Montgomery, $15.50; Patuxent River, $11, club license, $50; Prince George, $20.50 (upland game); Queen Anne, $5; St. Mary, $20.50 (upland game); Somerset, $2.75, nonresident of the State, $10.50; Talbot, $10 (upland game); Washington, $10.50; Wicomico, $10.50; Worcester (wild fowl), $10. Guests of landowners require no licenses, except in Allegany, Caroline, Dorchester, Garrett, Kent, Talbot, and Worcester counties. Nonresident taxpayers are usually exempt. In Somerset County residents are required to take out a $1.25 license, except to hunt on their own land, and in several other counties residents pay special licenses as follows: Anne Arundel, pusher, $2; booby and brush blind, $5; Cecil, Elk and Bohemia rivers, sneak boat, $5.50, sink box, $10.50; Queen Anne, booby blind, $2.50; Susquehanna Flats, sneak boat, $5.75, sink box, $20.75; Patuxent River, pusher, $2.50.

[c] The resident license law in Massachusetts does not take effect until Jan. 1, 1909.

[d] Members of incorporated game clubs owning real estate to the value of $1,000 and organized prior to 1907 pay a fee of only $1.

[e] United States soldiers stationed in the State and officers of the United States forest service classed as residents.

Details of hunting licenses and export regulations—Continued.

State.	Kind of license.	Fee.	By whom issued.	Details of license.	Export limit.
Nebraska	Nonresident	$10.00	Game and fish commissioner or county clerk.	Expires Dec. 31	50 birds.
	Resident	1.00	do	Necessary outside of county of domicile. Expires Dec. 31.	
Nevada					No export.
New Hampshire	Nonresident	10.00	Fish and game commissioners.	Expires Dec. 31. Not required of owners of real estate to value of $1,000.	2 deer, 12 birds.
	Alien	10.00	do		
New Jersey	Nonresident	10.50	County clerk	Expires Dec. 31	10 rabbits; 15 birds, if exposed open to view.
	Alien	10.50	Clerk of county, city, town, or other municipality.	Expires Dec. 31. Not required of owner or lessee of farm land hunting on land on which he resides.	
New Mexico					No export for sale.
New York	Nonresident	20.50	County, city, or town clerk.	Expires Dec. 31. Alteration of license a forgery	1 deer.
	Alien	20.50	do	do	
	Resident	1.10	do	Expires Dec. 31. Alteration of license a forgery. Not required of owner or lessee (or immediate family) occupying and cultivating farm land and hunting on such land.	
North Carolina	Nonresident[a]	10.25	Clerk of superior court	Good for season only	50 partridges or quail, 12 grouse, 2 turkeys, 50 beach birds or snipe.
North Dakota	Nonresident	25.00	County auditor	Expires Dec. 31. Nonresident owning or cultivating a quarter section of land may take out resident license in county where land lies.	No export.
	Resident[b]	.75	do	Expires Dec. 31. Citizen hunting on his own land exempt.	
Ohio	Nonresident	15.25	County clerk	Expires Dec. 5	50 animals and birds.
Oklahoma					No export.
Oregon	Nonresident	10.00	County clerk	Good for one year. Not required of landowners hunting on their own premises.	No export allowed, except by Washington hunters, who may take one day's bag.
	Resident	1.00	County clerk	Good for one year. Not required of landowners hunting on their own premises.	
Pennsylvania	Nonresident	10.00	County treasurer	Required of nonresidents and unnaturalized residents. Good for year of issue.	No export.
Rhode Island	Nonresident	[c] 10.00	Secretary of State	Expires Dec. 31	No quail, ruffed grouse, or woodcock.
South Carolina	Nonresident	10.25	County clerk	All game except quail and wild turkeys. Required of nonresidents and aliens. Good for season.	2 deer, 4 wild turkeys, 12 ruffed grouse, 50 each of partridges (quail), beach birds, ducks, geese.
	Nonresident	25.00	do	County license for shooting quail and wild turkeys. Not required of person hunting on land owned or controlled by him or when special guest of and accompanied by resident freeholder.	
	Market hunting	50.00	County treasurer	County license for residents hunting wild fowl on public lands and navigable waters. Expires Dec. 31.	

Tennessee	Nonresident	25.00	County treasurer	County license for big game. Issued Nov. 1. Expires Dec. 31. Nonresident licensee must be in charge of guide.	2 deer, 1 elk, 1 buffalo, 1 sheep, 15 birds.
	Resident	2.50	do		
	Nonresident	10.00	do	State license (birds) for season	
	Nonresident	10.25	State game warden	Expires Dec. 31. Not required of property owners who pay $100 in taxes.	50 ducks; 30 of allother birds in aggregate.
	Resident	3.00	do	Required when hunting on lands with verbal permission of owner. Expires Dec. 31.	
	Market hunting	25.00	do	Annual license; $200 bond required	
Texas	Noncitizen	15.00	Game, fish, and oyster commissioner.	Expires Dec. 31	3 deer, 75 ducks, 25 other birds.
Utah	Nonresident	10.00	State fish and game commissioner or deputy.	Required also of aliens; good to Jan. 31	No export.
	Resident	1.00	State fish and game commissioner or deputy; justice of the peace.	Not required of females; good to Jan. 31	
Vermont	Nonresident	15.00	State fish and game commissioner.	Deer. Good for season[d]	1 deer; no birds.
	Nonresident	[e]5.00	Town clerk	Birds only[d]	
Virginia[f]	Nonresident	10.00	County clerk	Good in open season in the 6 months following issue.	1 deer, 50 quail, 10 pheasants or grouse, 3 wild turkeys, 30 waterfowl, 25 of each or 100 in all, plover, snipe, sandpipers, willets, and tatlers.
Washington	Nonresident	10.00	State auditor	State license. Good for 1 year	A season's limit of big game and a day's limit of birds.
	Nonresident	5.00	State or county auditor	County license. Good for 1 year	
	Alien	50.00	do	State or county license. Nonresident. Good for 1 year.	
	Resident	5.00	State auditor	State license. Good for 1 year	
	Resident	1.00	State or county auditor	County license. Good for 1 year	
West Virginia	Nonresident	16.00	State game warden	Good for 1 year. Not required of landowners hunting on their own property.	No deer, quail, ruffed grouse, pheasants, wild turkeys.
Wisconsin	Nonresident	25.00	Secretary of state		1 deer, 30 birds.
	Nonresident	10.00	do	All game except deer	
	Resident[g]	1.00	County clerk		
Wyoming	Nonresident	50.00	Justice of the peace	Expires Dec. 31. Required also of aliens. Each licensee must employ guide.	2 deer, 1 elk, 1 antelope, 1 sheep.
	Nonresident	5.00	do	Birds only. Expires Dec. 31	
	Resident[h]	2.00	do	Expires Dec. 31	
	Resident	1.00	do	Birds only. Expires Dec. 31	
	Guide[i]	10.00	do	Good for one year.	

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[a] A $25 license is required for shooting wildfowl from blind, battery, box, float, or raft in the waters of Dare County lying north of an east-and-west line passing through northern end of Roanoke Island; south of said line 2 nonresidents may shoot from such devices belonging to a resident if a $5 tax has been paid upon same.

[b] Residents of the State under 16 years may hunt without license, but must have written consent of their parents.

[c] Members of incorporated game clubs owning real estate to the value of $1,000 and organized prior to 1907 pay a fee of only $1.

[d] Not required of anyone owning real estate in Vermont, occupying the same as a domicile at least three months in the year, and paying taxes thereon.

[e] A nonresident holding a bird license may secure a deer license by paying $10 additional.

[f] Guests not required to procure license to hunt on land of host, provided the host receives no compensation, directly or indirectly, from such guest.

[g] Bona fide settler who has not resided in the State 1 year may take out a special resident license.

[h] Applicant must be an elector of the State; child or ward, over 14 years, of an elector; or a soldier or sailor of the United States and an elector thereof, stationed 1 year at a post in the State. Soldier or sailor must employ guide.

[i] Guide must be citizen and qualified elector of State, must act as assistant game warden, and is equally responsible with employer for violation of law.

Details of hunting licenses and export regulations—Continued.

State.	Kind of license.	Fee.	By whom issued.	Details of license.	Export limit.
Alberta	Nonresident	$25.00	Minister of agriculture	Expires Dec. 31	Under general license, trophies of big game legally killed.
	Nonresident	15.00	do	Birds only. Expires Dec. 31	
	Guest	2.00	Game guardian	Guests of residents. Good for 5 days	
	Guide, camp help	5.00	Minister of agriculture	Resident maximum fee. Expires Dec. 31	
	Resident	2.50	do	Big game. Expires Dec. 31[a]	
	Market hunting	10.00	do	Expires Dec. 31	
British Columbia	Nonresident	100.00	Game warden or any government agent.	Members of army or navy or Canadian militia in actual service exempt.	Heads, hides, and horns of animals legally killed by nonresident licensees.
	Nonresident	5.00	do	Birds only. Good for 1 week	
Manitoba	Alien	100.00	Minister of agriculture and immigration.	Nonresident. Good for season	2 heads and skins of each species of game animal, 50 ducks, 100 geese, or swans, and any other game bird, except partridge, grouse, and prairie chicken under permit of minister of agriculture and immigration.
	Nonresident	25.00	do	British subject	
	Resident	2.00	do	Big game only	
New Brunswick	Nonresident	50.00	Surveyor-general; chief game commissioner; any game warden.	Moose, caribou, and deer[b] (any game in Westmoreland County).	No partridge; other game under permit.
	Nonresident	10.00	do	Deer only. Discretionary with surveyor-general	
	Nonresident	10.00	do	Game birds	
	Resident	2.00	do	Moose, caribou, and deer	
	Resident	.25	do	In Westmoreland County	
	Guide	1.00	do	Resident accompanying anyone hunting big game	
	Camp help	1.00	do	Resident	
	Camp help	50.00	do	Nonresident	
Newfoundland[c]	Nonresident	51.00	Stipendiary magistrate; justice of the peace; minister of marine.	Good for season. Licensee can not employ unlicensed guide.	3 caribou under license and permit.
	Guide	50.00	do	Nonresident. Resident guide licenses free	
Nova Scotia[d]	Nonresident	30.00	Provincial secretary, board of game commissioners.	Expires Aug. 1. Must employ licensed guide	1 moose lawfully killed by licensee.
	Resident	5.00	do	For shooting woodcock and English snipe outside county of residence. Expires Aug. 1.	
	Guide	2.00	do	Resident. Expires Aug. 1	
Ontario	Nonresident[e]	50.00	Superintendent of game and fisheries.		2 deer, 1 bull moose, 1 bull caribou lawfully killed by licensee.
	Resident	5.00	do	Moose and caribou	
	Resident	2.00	do	Deer	
	Guest		do	No fee required. Good for 1 week or less	
	Nonresident	25.00	do	Ducks and other small game	100 ducks lawfully killed by licensee.
	Guide	2.00	do	Maximum fee	
Prince Edward Island.	Nonresident[f]	15.00	Game inspector	All game. Expires 1 year after date	12 birds (except geese and brant, on which no limit is placed).

336 Saskatchewan	Resident[h]	5.00	[illegible], and fisheries or his agents.	[illegible]	
	Nonresident	100.00	do.	3 deer and 3 caribou additional to bag limit.	
	Nonresident	50.00	Game guardian	Expires Dec. 31.	Under general license, trophies of big game legally killed.
			do.	Birds only. Expires Dec. 31.	
	Guest	1.00	do.	Guests of residents hunting with them. Good for 5 days.	
Yukon					

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[a] Not required in northern Alberta.

[b] Nonresidents hunting big game must be in charge of registered guide.

[c] Any officer of a British war ship stationed on the coast of Newfoundland for fisheries protection may obtain a free hunting license good for six weeks of open season and may employ an unlicensed guide.

[d] Nonresident landowners paying $30 or more annual taxes and officers of the army or navy stationed in Nova Scotia pay $5 fee.

[e] Lieutenant-governor in council authorized to reduce license fees charged residents of other Provinces to rates corresponding with those residents of Ontario are required to pay in such Provinces.

[f] Nonresidents paying taxes on real estate in Prince Edward Island to value of $325 pay a fee of only $5.

[g] Active members of any incorporated fish and game club that leases a hunting reserve pay a fee of $10.

[h] No fee required of poor Indians or settlers, in discretion of Minister of colonization, mines, and fisheries.

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FARMERS' BULLETIN 337.

CROPPING SYSTEMS FOR NEW ENGLAND DAIRY FARMS.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., July 30, 1908.

Sir: I have the honor to transmit herewith a paper entitled "Cropping Systems for New England Dairy Farms," by Mr. L. G. Dodge, Scientific Assistant, Farm Management Investigations.

This paper gives the results of three years' study of the cropping systems on a number of the most successful dairy farms in New England. This study has enabled Mr. Dodge to point out the elements which go to make a satisfactory cropping system in that section and to make definite recommendations concerning crops to plant and the relative acreage of these crops on dairy farms. I recommend that this manuscript be published as a Farmers' Bulletin.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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OPPING SYSTEMS FOR NEW ENGLAND DAIRY FARMS.

INTRODUCTION.

w England is preeminently a section of small farms, due largely
e generally broken character of the country, the farming land
g located in small areas scattered among the hills. Since the
s are small, some type of intensive farming must be followed to
e them profitable. Since the land has already been tilled longer
good land will bear an exploitive system of farming, some type
ve-stock farming is a necessity on most farms. As the most in-
ve form of stock farming is dairying, this latter industry is nat-
y the leading one on New England farms. Dairying, in the main,
been a profitable business in New England, but in recent years
itions have changed, and the outlook is not so satisfactory as it
been at various times in the past.

me of the difficulties which are at present most evident are the
prices of concentrated feeds and of labor. Some sections of New
land, furthermore, feel the pressure of unsatisfactory market con-
ns, especially those sections which ship milk to the large cities,
e the farmers are offered a price for their milk on which they
hardly make a profit.

tside of the milk-shipping sections the difficulties mentioned do
appear, on careful observation, to be the most fundamental, al-
gh they are the most obvious. Taking the Northeastern States
e Union as a whole, owing to climate and topography the land
general adapted to the growth of grass and trees. The fact that
s is so much at home in those States has led to a serious fault in
England dairy farming, namely, the mismanagement of grass
s. This consists in the main of a lack of proper treatment for
anent grass lands and of suitable rotations for other land, as well
he use for grass growing of land which does not give profitable
rns from grass and which should rightfully be devoted to tree
th, either as woodland or orchards. Another frequent and wide-

spread fault is the habit of cutting the hay crop entirely too late in the season, which of itself shortens the life of the meadow and results in an inferior quality of hay for dairy feeding.

Closely associated with poor management of grass lands is the failure to utilize other crops available for this section, especially corn. In southern New England there is little difficulty in growing good silage corn, but as one travels northward there is evidence of a lack of suitable varieties of corn for silage. This difficulty is not insuperable. There are varieties of corn that can be grown for silage in all but the most northern counties in New England. What is most needed is that sufficient attention be given to the selection of seed in order to develop strains of corn fitted to the requirements of the different sections.

Some of the best dairy farms of the country are to be found in New England. They are scattered here and there all over the New England States. A careful study has been made of the cropping systems on a large number of these farms. The results of this study are set forth in the following pages. No recommendations are made here that are not already known to have been practiced on profitable dairy farms in the section concerned.

CROPPING SYSTEMS DESCRIBED.

FARMS IN NORTHERN NEW ENGLAND.

In the northern part of New England there are several dairymen who have demonstrated that the average dairy farm there is working at only a small fraction of its capacity. Among them the Hon. C. L. Jones, of Penobscot County, Me., raises all the roughage and some of the grain for 40 head of cattle, 4 horses, and 20 sheep on 40 acres of tillage, and spares from this area 3 or 4 acres for potatoes every year. About 12 acres of flint corn are grown each year for silage, nearly as much small grain, a mixture of oats and barley, and the remainder of the 40 acres, aside from the potatoes, is devoted to hay. The rotation comprises one year of corn, one of small grain, one of clover hay, and part of the land is run for mixed hay a second year. The land is seldom left in hay more than two years before it is again plowed up for corn, making either a three-year or a four-year rotation.

The manure is mostly applied in the late summer and fall with a manure spreader, both as a top dressing to the new seeding or other grass land and to the land to be used for corn the next year. It is applied at the rate of ten loads per acre for either purpose. The seeding is done with the grain in the spring. Mammoth clover is seeded at the rate of 12 to 14 pounds to the acre, with 2 or 3 pounds of redtop and 4 quarts of timothy. The result of the short rotation quent manuring, and the heavy seeding is a crop of 3 tons of the acre at one cutting. Other crops yield in proportion, so is farm furnishes feed for so large a number of stock that it nreasonable to the average dairyman. The results of Mr. methods are readily apparent upon looking at his hay crop, illustrated in figure 1. The photograph was taken where the had just passed.

arm of Mr. Paul Ames, of Kennebec County, Me., furnishes instance of high farming on a small acreage. This farm s the forage for 11 grown cattle, 3 young cattle, and 2 horses.

—Mammoth clover on farm of C. L. Jones, Penobscot County, Me. Photographed early in July.

are 40 acres of pasture for summer feed. The tilled land nts to 16 acres, of which about 11 are used for grass and clover for peas and oats, and 1 for potatoes. The land is not adapted n growing owing to its moist condition, but produces two crops each season. As much as is used for peas and oats is seeded, with the grain, with 10 pounds of red clover, 1 peck of timothy, pounds of redtop to the acre. This seeding is done about the e of May, and the peas and oats are cut for grain about the e of August.

grass land yields a cutting of hay between the 1st and the 10th y, or even beginning in June, and a second crop about August 20. re the second crop it is allowed to wilt, then put in the heap [illegible] left for three days. The two cuttings yield upward of 3 tons per acre of a very fine quality. Before it is plowed again the condition of the grass land is kept up four and even five years by an annual application, after haying, of 9 or 10 loads of stable manure per acre as a top dressing.

Mr. Ames's cows averaged in a recent year 230 pounds of butter fat. Counting the value of cream actually sold and grain purchased, both taken from careful records, he says that the hay is worth $18 a ton to him, allowing each cow 2½ tons per year. This shows what a good quality of hay will do under circumstances which prevent the growing of silage corn. In addition to his other stock, Mr. Ames keeps 10 or 12 hogs, to which he feeds the skim milk.

One of the first men to show to Maine dairymen the possibilities of their land was the late R. W. Ellis, of Somerset County. He long since demonstrated that an acre of sweet corn grown in a short rotation on land kept in good condition by frequent application of manure would yield from 10 to 12 tons of silage after the well-filled corn was picked for the cannery. He also showed that with grain alone silage from this corn at the rate of 60 to 70 pounds a day would keep a cow in condition. The acre of sweet corn, then, would easily provide roughage for a cow for two hundred days during such part of the year as she could not be pastured. Mr. Ellis further demonstrated that every acre of good quality hay grown on land, likewise in good condition from the short rotation and judicious manuring, would furnish roughage for a cow for the year and to spare, outside of the pasture season. The quality of his hay was made fit for dairy cows by seeding heavily to clover, at the rate of 6 pounds of red clover and 4 pounds [illegible] alsike to the acre, together with the usual peck of timothy. Wh[illegible] these two feeds, the silage and the mixed hay, are combined he [illegible] excellent roughage for dairy stock.

The opportunities in New Hampshire for the developing of pro[illegible]able and intensive dairy farms have not been demonstrated nearly [illegible] plainly as they have in Maine. For one thing, the majority of N[illegible] Hampshire dairymen are confronted with the unsatisfactory mar[illegible] conditions already mentioned which are attendant on shipping [illegible] to the large cities. Again, many farmers in New Hampshire have [illegible] recent years depended on summer boarders, putting too much reli[illegible] in the statement that this is the only profitable crop they can cultiva[illegible] since their lands are poor and the scenery the principal natural [illegible] of the State. They have likewise paid too little attention to [illegible] intensive development of profitable dairying.

Prof. J. W. Sanborn, however, has been demonstrating for [illegible] time what may be done to improve New Hampshire farms by a[illegible] intensive system and a short rotation, and though his work has [illegible] done on a large scale so far as acreage is concerned, his rotatio[illegible] adaptable to the smaller acreages which, on account of the broken topography, are the only ones available to many New Hampshire dairymen. Professor Sanborn has on his large farm some 400 acres of tilled land suited to frequent plowing and rapid rotation, besides 100 acres of permanent meadow, and another 175 acres of permanent pasture.

The 400 acres of easily plowed land are put in a rotation as follows: Corn, one year; peas and oats for hay, one year; clover for hay, two cuttings, one year; potatoes to sell, one year; Hungarian millet for hay, one year; timothy for hay to sell, two years, and then one year of pasture.

This is virtually two good rotations, one following the other, the two covering eight years, and gives 50 acres in each lot of land, allowing 50 acres for potatoes, 100 acres for hay to sell, and 250 acres to raise roughage for the live stock. Of this 250 acres, 50 are in good pasture after the hay is cut and before plowing for corn again. This leaves 200 acres for hay and silage, which, together with 100 acres of permanent meadow, 50 acres of pasture in rotation, and 175 acres of permanent pasture, provide roughage for 140 milk cows the year round, and during the winter for some 100 additional head of young stock which are pastured at a distance in the mountains during the summer. The grains for the supplementary feeding are necessarily purchased.

The hay from the whole of the cleared land in 1894, when Professor Sanborn took the farm, amounted to 112 tons. In 1905 the yield was 800 tons, this increase being accomplished by frequent plowing of the land and frequent applications of manure, which serves to illustrate on a large scale what has been shown already in other places in New England, namely, that land which can be plowed conveniently, and is therefore adaptable to a rapid rotation, can by this kind of treatment generally be made to produce the roughage[a] necessary to keep a cow for each acre, at least, if it be supplemented with pasture for part of the summer feed of the cow.

The fundamental principle on which Professor Sanborn is working is that it is fully as much the amount of milk or butter produced per acre which counts as it is the amount per cow, and he is developing the land accordingly. To build up a dairy farm on a small acreage, of course, it becomes necessary to leave out the potatoes and hay to sell and to devote all the tilled land to the support of the herd.

As an illustration of what may be done in this direction in New Hampshire, the farm of Mr. D. H. Noyes, of Grafton County, may be cited. This farm comprises 18 acres of tillable land and 150 acres of rough pasture. The tilled land is kept in a four-year rotation of one year each of corn for silage, oats for hay, clover hay, and mixed hay, and provides the coarse feed for 11 cows, 3 young cattle, 3 horses, and 32 sheep. The grain purchased amounts to only 1 ton per month as an average for the year.

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[a] The term roughage is equivalent to the expression "coarse fodder" [illegible] quently used in New England, including hay of all kinds, sil[illegible]

In Vermont there are some of the best object lessons in dairying that are to be found in New England. In the dairy sections of that State one very frequently hears of a small dairy farm of from 100 to 200 acres in all, rough land included, which has given the owner an average of $1,000 a year profit above his living for the past two decades. This high state of development of dairy farming in Vermont is not so much due to the quality of the soil as it is to the systems of cropping and fertilizing the land.

The farm of C. F. Smith, of Lamoille County, is an admirable example. On this farm 75 acres of tilled land, with as much more in pasture, provides the roughage and part of the grain for 55 milk cows, 25 young cattle, and 8 horses. The pasture provides feed for the young cattle during the summer, but the cows get some feed in the barn at all seasons, even when the pasture is at its best.

From 20 to 25 acres of the tillable land are taken up every year with corn for the silo, as much more with oats or a little barley or Japanese millet, and the remainder with clover and timothy hay. This necessitates frequent plowing of the land in rotation, giving one year of corn, one of small grain, then one year, or in part two years, of hay on each lot. The result is that this plan, together with frequent manuring, gives to the acre, even in this northern part of the State, 15 tons of ensilage and 4 tons of hay, and oats have at times yielded 90 bushels.

Hay is cut during the last days of June or early in July, and again early in September. This practice, together with that of allowing the land to grow hay only one year, or two at the most, results in an average of 4 tons of hay per acre, two cuttings, and that of a very fine quality for dairy feeding. Any hay which is cut in unfavorable weather is put into an old silo, a new and much larger one having been built for the corn.

In seeding his grass, Mr. Smith uses a peck of clover, a peck of timothy, and 10 pounds of redtop to the acre. The manure is applied as a top dressing in the fall to the grass lands, then hauled out several times during the winter to the land set aside for corn the following spring. Any corn land remaining is supplied in spring after the ground is dry enough to haul over. Mr. Smith attributes his success to his frequent plowing of all his land and his method of applying manure, especially top dressing.

The possibilities of another type of cropping system are exemplified by that in use on the farm of F. E. Wilson, of Chittenden County.

This farm consists of about 65 acres of tilled land and 60 acres of rough land, which furnishes sufficient pasturage for the present live stock for nearly four months in the year. On the farm are kept 35 cows, 10 to 15 young cattle, and 5 or 6 horses, and the only feed purchased for them for the entire year is about a ton of cotton-seed meal and 2 tons of bran.

The rotation followed is corn for silage, one year; a mixture of peas, oats, and barley for grain, one year; and hay, two years. This four-year rotation allows about one-half of the 65 acres to be in hay each year, a fourth in silage corn, and a fourth in grain. The mixture of peas, oats, and barley is thrashed and ground and fed to any or all of the live stock as needed, with the slight addition of the purchased grain already mentioned.

With this cropping system, even though well supplemented by summer pasturage, it will be noted that the number of live stock is not equal to the number of acres of tillage, but it will be further remarked that the bill for purchased grain is reduced to a minimum. Frequent plowing and the application of manure have, as in the other cases, made this degree of intensity possible. This farm has found one solution of the problem now so pressing, namely, that of purchasing grain. Another solution of this same problem is exhibited by the system of crops on the farm of H. B. Chittenden, also in Chittenden County.

The Chittenden farm comprises 175 acres of tilled land and some 75 acres additional of rough land which furnishes pasturage for only about two months for the present number of cattle on the place. This pasture season lasts only from the middle of May to the middle of July; the other ten months of the year a full winter ration is required. On this farm are kept approximately 110 cows, 25 young cattle, and 15 horses. Besides supplying this stock with the required coarse fodder, some 90 to 100 tons of hay are sold each year, thus furnishing from the farm an equivalent for the grain purchased.

The rotation on a large part of the 175 acres is silage corn one year, followed by two years of clover and timothy for hay. The remaining smaller portion of the land is run in a four-year rotation of silage corn, one year; part peas and oats for hay and part millet for hay, one year; and clover and timothy for hay, two years. In the case of the three-year rotation the grass is seeded in the corn late in July with a wheelbarrow seeder. The corn is cut for silage with a corn harvester in September, and the grass makes two hay crops the following season. All hay, in fact, is cut twice in a season, whether in the first or second year or whether seeded in the corn or with the small grain crops, and it yields from 2 tons upward at each cutting.

All the seeding is done at the rate of 1 peck of timothy, 8 quarts of red clover, and 4 quarts of alsike clover to the acre, wh[illegible] corn or otherwise. Manure is applied to all of the land every yea the rate of 10 or 12 spreader loads per acre, whether to the gras top dressing or elsewhere.

One of the most intensively operated farms that has come to no in Vermont is that of F. L. Davis, of Windsor County. This f comprises 96 acres in all, of which a scant 30 is tillable, about more being in pasture, and the remainder is in woodland.

This farm produces all the coarse fodder for 25 milk cows, 15 yo cattle, and 6 horses. About 6 acres are put in corn for silage e year, 2 acres in peas and oats for hay, and the remaining tilled l is in hay.

Hay is raised on any field two years only, as a rule, but part of land sometimes runs a third year. The first crop of hay is cut v early, usually beginning about June 25, and a second crop is cut the end of August. The annual yield per acre averages very close 4 tons. The newly seeded fields often produce 3 tons at the fi cutting and 2 at the second, of the finest quality of hay, mostly clov The quantity of hay in a second crop of this clover is shown in figure The field shown had already yielded nearly 3 tons per acre at th first cutting, having been seeded in corn the year previous. Th adjoining field of corn has been seeded for hay for the year followin The seed used amounts to 20 quarts per acre, of which half is clov The seeding is done in the corn late in July, with very satisfactor results.

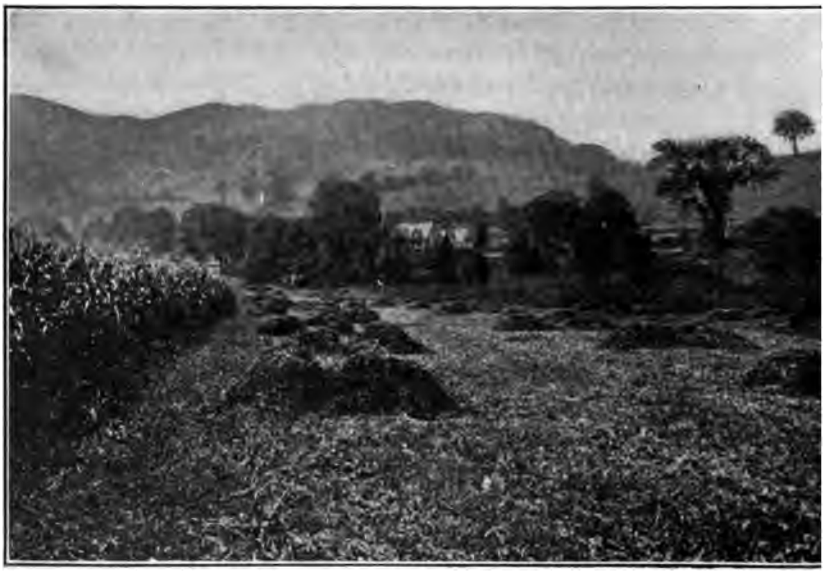

FIG. 2.—Second crop of red clover on farm of F. L. Davis, Windsor County, Vt. Photogra at the end of August.

The only commercial fertilizer used on the farm is 200 pounds per acre on the corn. The manure from the relatively large herd is applied to all the crops, on the corn land during winter or spring and as top dressing on the grass. This farm in 1890 could scarcely support 12 cows, 2 oxen, and a pair of horses. It was raised to its present state of productiveness first by applying commercial fertilizer, especially that high in potash, to all the land until a good clover stand was obtained. Then the further increase was accomplished by the use of the clover in increasing the number of live stock as well as the humus in the soil, and the increase of live stock was further aided by the additional manure. After the clover was once established the use of commercial fertilizer, with the exception of that used on the corn, was discontinued.

FARMS IN SOUTHERN NEW ENGLAND.

In southern New England the same cropping systems that have been described in Vermont work admirably, and with even greater success, owing to the fact that corn will make a somewhat larger yield of ensilage. In addition to examples of the kind of cropping systems already described, there are in Massachusetts some instances which illustrate methods suited to rather different conditions. When for one reason or another land is not well suited to corn growing it may still be made to support a relatively large number of cattle.

Mr. William B. Avery, of Franklin County, Mass., frequently winters 20 cows and 6 or 7 horses on the roughage from 18 acres of land. Most of this acreage remains in grass for five years at a time. To renew the seeding of each lot after that length of time it is usually plowed after the first crop of hay is off, perhaps during the latter part of July, and after being turned about 8 inches deep is rolled, then dressed with 15 spreader loads of barnyard manure, harrowed thoroughly twice with the spring-tooth harrow, sowed with a mixture of timothy, red clover, and alsike clover, and rolled again. This land is a stony loam, and at that season of the year rolling only helps make the surface moist enough for the seed to germinate.

The grass and clover both get sufficient start before freezing weather to survive the winter in good condition and produce two good crops of hay the following season. Two crops are cut each year thereafter. The yield is kept up during the five years by an annual top dressing of stable manure rather lighter than the application used in seeding down. By this system four years out of five the land produces two good crops of hay, and the fifth year it produces one crop before it is reseeded for another five years.

Sometimes an acre or so of corn is grown on part of the land that is to be reseeded. In that case the corn is cultivated level and the seeding is done broadcast in the corn about July 25, a full month earlier than is necessary when seeding alone, as previously described. When seeding in the corn a somewhat larger amount of seed is used than when seeding alone.

In this connection it is well worth noting that a few farmers in New York State follow a plan much like that described above, with this addition: They apply 4 or 5 pounds of mixed red and alsike clover seed to the acre on the old sod each spring. Sometimes this is done by sprinkling a proportionate amount of the seed on each spreader load of manure as it goes out for top dressing, or if the top dressing is done in the fall the clover is sown broadcast by the man who drives the brush harrow over the grass land in the spring, the brush harrow then accomplishing two purposes, that of breaking the clods of manure and that of working the seed into the surface soil. This addition of clover seed is of great advantage to the dairyman, for it keeps up the mixture of clover in hay grown on land which it is impracticable to plow more frequently.

There is another type of cropping system which appears to be adapted mainly to farms located close to some large city, where land is scarce and the demand for milk is so good that the farmer needs a greater proportion of silage or other succulent feed, even at the cost of buying some hay. This plan is to grow a series of crops which furnish green feed from the middle of May to November 1. So much of each crop as may be is fed green. When a crop reaches the stage of maturity where it would no longer be fit to feed green, it is made into hay or put in the silo. This allows of increasing the quantity of succulent feed without using all of the land for corn, and thus distributes the labor of men and teams through the season in a way which could not be done in growing the same acreage of corn alone.

In the vicinity of Boston, rye sown September 10 is ordinarily fit to cut for feed May 15 and lasts until about June 5. Winter wheat and vetch sown September 20 is fit to feed from June 5 to July 1, and any left over makes good hay. Oats and peas sown first April 18 will be fit to feed by July 1, and successive seedings, even up to July 1 on low land, will furnish green feed until September 1. If the later seedings must be omitted for lack of suitable land, green corn planted May 15 will fill the gap until a frost comes. Barley sown from June 20 to August 15 in successive lots will furnish feed for September and October. Under any other circumstances than those I have described it does not seem economical to follow this system, for summer feeding of silage saves the daily labor of cutting and hauling a green crop on any farm where there is land enough to use for growing good clover hay in a rotation with silage corn. In this connection it is well to note the heavy clover crops grown in that manner, as illustrated in figures 1 and 2.

There are considerable sections in southern New England where ll the dairy farms are engaged in supplying milk to the numerous maller cities. Such is the case not only in part of Massachusetts but n considerable portions of Rhode Island and Connecticut.

Within the city limits of Providence, R. I., there is an example of cropping system much like that just described, where on 60 acres re grown silage, soiling crops, and hay sufficient for 7 horses and 60 ows the whole year and 40 additional cows for nine months. The first ear this cropping system was instituted it was necessary to buy 4 arloads of hay, the second year 1 carload, and the third year none would have been needed for this number of stock, but 2 carloads were bought because 100 cows were kept for a much longer season than before. Enough hay was made from the oats and peas, the millet, and other similar crops to supply that needed for the original number of cows, and enough mixed clover and timothy was grown for the horses.

R. L. Sadd, of Windsor County, Conn., on 80 acres of land provides roughage for 40 cows and 7 horses and is at present accumulating a surplus of hay and silage to provide for an increase in the number of cows. About half of his land is too low and moist for corn, but is xcellent grass land, while 30 acres of the farm is upland, on all of which corn is grown every year and which is especially suited to this rop. Of the 50 acres of permanent meadow, 5 are sufficiently dry for alfalfa, and by especial care a good stand of this crop has been btained on that area.

These conditions make it rather difficult to keep up the production f both corn and grass; but by manuring the corn land every year with 2 loads to the acre and by top dressing the grass land frequently and eseeding it generously the production of corn is sufficient to furnish ilage for the present herd and the grass lands supply sufficient hay. Much of the corn land is also sowed to rye in the fall, which is plowed nder for the corn again in the spring.

The herd is constantly growing as the crop yields increase. By the nd of this year the herd will consist of 54 cows and 1 bull. The dditional manure promises to increase the yields sufficiently to furish roughage for the added stock.

Because of the impracticability of rotating crops on this farm, Mr. add has found that it requires $10 worth of commercial fertilizers to roduce the necessary coarse fodder for each cow, but with this mount of fertilizer he has accumulated sufficient feed to provide for e season with the increased number of stock. It is to be rememered that the cows get no pasture at all, but are stall fed the entire ear. It seems probable that when the number of cows reaches the aximum the cost for additional fertilizer will be somewhat less than ow. At best, however, Mr. Sadd feels the effects of the inability to use rotation of clover and corn in the added expense of growing his crops.

Mr. Thomas Holt, also of Hartford County, Conn., has a farm comprising 74 acres of tilled land, on which he keeps 70 head of grown cattle, 25 young cattle, and 6 horses. All of the roughage for this stock is provided for the entire year, except that some of the young cattle are kept on hired pastures during the summer. The pastures on the farm do not count as feed, as they are little more than an exercise lot for a herd of 70.

The rotation is usually one of three years, but is sometimes extended to four. Corn for silage is grown one year. As soon as the crop is off in September the land is harrowed thoroughly and sown broadcast to rye. As early the next spring as a team can be put on the land, the rye is gone over four or five times with the smoothing harrow and seeded broadcast before the last harrowing with 15 pounds of red clover to the acre. The harrowing is done entirely regardless of the rye and with the sole purpose of preparing a good seed bed for the clover. The rye is so hardy, however, that it soon recovers from the harrowing and makes an excellent crop for green feed or other uses. Some of it is cut and fed green, but the greater part is made into hay or chopped into one of the silos, which by that time is empty. A little of the rye, sufficient for seed the next year, is left to ripen. If the season be favorable—that is, not too dry—two crops of clover are cut after the rye which is cut green, and one after the rye cut for grain. Then the clover is top dressed in the fall and cut either two or three times the second year, according to the season.

In most cases this ends the rotation and corn begins again. In some lots, however, this rotation is varied by planting corn two years in succession before seeding clover. In that case the corn stubble of the first year is sown to rye just the same, and the rye is plowed under for the second crop of corn. Rye follows the corn again the second year and the clover is seeded in this the next spring.

Another variation is that of cutting the rye without sowing clover, following it with Japanese millet, and seeding clover in the millet. The millet may be fed green in part, but most of it is put into the silo, for which purpose it is as satisfactory as corn.

The several sources of silage give sufficient succulent food to compensate for the scanty pasturage, and the variety of crops used no doubt makes the silage more palatable. The manure is hauled from the barn every day in the year, for at most seasons there is some place to spread it. About 800 loads a year are produced, and this covers all the land once. Besides the manure some Canadian hard-wood ashes have been applied to each field in succession for the purpose of improving the clover stand. The result has been to insure such a growth of clover as has been described—two or three crops a year.

At least half of the present tilled land was not long since in rough and very stony pasture and has been cleared of stones a field at a time.

m is on a hilltop which is far from smooth. The whole system agement of crops, live stock, and labor on Mr. Holt's farm is so tory that it is planned to treat it more fully later in a separate 1.

CONCLUSIONS.

rder to present the relation of the number of live stock to the under the several systems of crop production, the figures for eral farms have been tabulated as follows:

.—*Acreage of New England farms discussed in this bulletin, and number of live stock on each.*

	System.		Tilled land.	Pasture.	Number of cattle.		Tillable land per animal.[a]	Pasture per animal.
					Cows.	Young stock.		
			Acres.	*Acres.*			*Acres.*	*Acres.*
	Silage	Grain purchased	40	40	25	15	[b]1.09	1.00
	do	do	[c]200	225	140	100	1.05	.9
	do	do	18	150	11	3	.95	([d])
	do	do	75	75	55	25	1.10	.93
n	do	do	175	100	110	25	[e]1.40	.75
	do	do	28	36	25	15	.83	.9
	do	do	74	40	70	25	.89	.42
	do	do	80		45		1.77	([f])
	do	Grain raised	65	60	35	12	1.56	1.28
	No silage	Grain purchased	16	40	11	3	1.23	2.85
	do	do	18		20		.90	

I.—*Acreage of the several crops on New England farms discussed in this bulletin, and percentage of land in each crop.*

Farm.	Tilled land.	Approximate number of acres [g] in—			Tillable land.		
		Corn.	Other cereals.[h]	Grass and clover.	In corn.	In other cereals.[h]	In grass and clover hay.
	Acres.				*Per cent.*	*Per cent.*	*Per cent.*
	40	12	10	14	30	25	[i]35
	200	50	100	[j]150	25	50	25
	18	4.5	4.5	9	25	25	50
	75	22	22	31	30	30	40
n	175	58	17	100	32	10	58
	28	6	2	20	21.5	7.5	71
	74	25	20	29	34	25	.31
	80	30		50	37.5		62.5
	65	16	[k]16	32	25	25	50
	16		4	11		25	[i]70
	18	[l]2		16	11		89

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st of these farms 2 horses are kept for each 18 or 20 cattle. The horses do not use any pasture, be counted in connection with the crops raised. In reckoning tillable land or pasture per young cattle or 5 sheep are considered the equivalent of 1 cow.

koning tillable land per cow only that used for raising feed is counted.

s on the Sanborn farm refer only to the part used to supply dairy feeds.

Noyes farm 32 sheep are kept in addition to the cattle, and so the surplus pasture is partly

erable hay is sold annually from the Chittenden farm.

is no pasture on the Sadd farm. Cows are stall fed the year around.

figures are only approximate, for the acreages vary slightly from year to year.

es either Japanese or Hungarian millet on a few farms.

Jones and the Ames farms, respectively, a small area out of the tilled land is used for potatoes.

es 50 acres of permanent pasture.

except the Wilson farm other cereal crops than corn are used for hay or silage. On the Wilson are cut for grain.

n raised is for silage except on the Avery farm, where corn is raised for grain, and figures y only to winter feeding.

When the results attained on the several farms just described are considered, it will be seen that there are three factors which have contributed most to the results: First, the proper use of stable manure second, putting into a short rotation all land suited to it and, third the proper handling of land which is suited only to grass.

A short rotation of three or four years, such as described in connection with several of the farms—for instance, those of Messrs. Davis and Holt—accomplishes three things. The first and most frequently recognized is the turning down of a good sod, especially a clover sod. every third or fourth year, a practice which furnishes a large supply of humus and fertilizing material, thereby producing larger yields of corn, small grains, or other crops. Secondly, the frequent breaking up of the sod, growing a tilled crop, and then seeding down again keeps up the yield of grass during such part of the time as the land is producing a hay crop. This increase in yield of hay is largely due to the clover, which can not be kept in the hay more than two years without reseeding, since it is a biennial. For these reasons it is obvious that such clover crops as those shown in the cuts contribute both directly and indirectly to the success of these cropping systems. Thirdly, a short rotation permits the growing of some cash crop like potatoes on part of the land, and that without seriously depleting the soil, as is likely to occur when a crop of that kind is grown on the same lot continuously.

When land is suited to grass growing only, as is frequently the case with land in New England, either on account of being too moist or from having too many rocks at a short distance below the surface to allow frequent plowing, the problem of keeping up the yield is more difficult. This problem is solved, however, by some of the farmers whose work has just been cited. The essentials in keeping up the yield of permanent grass land on a dairy farm in New England appear to be, first, the applying annually of small quantities of barnyard manure as a top dressing. Eight or 10 spreader loads per acre each season are much better than 20 or 30 loads every second or third year. If the farm does not have a manure spreader on it, it is somewhat more difficult to apply so light a coating, but when spread as well as possible by hand a brush harrow will break up the lumps and scatter them satisfactorily.

The use of a large proportion of clover seed when seeding down gives a better quality of hay for two years at least, and the clover improves the yield of the true grasses which are sown with it. Not only that, but it has been shown that the addition of small amounts of clover seed on top of the old sod in the spring is profitable.

It will be noted that with successful dairymen in New England one of the most general practices is that of cutting the hay crop early which not only allows the cutting of a second crop, like that shown

gure 2, but gives a far better quality of hay for making milk.
cuttings yield more and better hay than the one late cutting.
ay be well to explain that by early cutting is meant a time before
of the grasses or clovers in the mixture have had time to ripen
get dry and hard. As far north as Windsor County, Vt., in a
nal season, Mr. Davis's hay harvest is found to be in full swing
'une 27.

r practicing the fundamental rules in crop production just
ribed, namely, the intelligent use of manures, the following of
t rotations, and the good management of grass lands, many
ymen are already doing as much as can be done by the individual
ıer toward solving the two obvious difficulties of getting the nec-
ry concentrated feeds to supply protein in the feeding rations and
ıeeting the scarcity of farm labor. The first of these difficulties
medied because the methods practiced result in a far more pal-
ıle as well as more nutritious quality of coarse fodder in the
ht, early-cut hay, in the corn ensilage, and especially in clover
peas in the hay.

hese last two classes of hay do a great deal toward supplying the
ein of a dairy ration, and the small grain that is grown on several
he farms described supplies still more, whether it is fed in the
w, as the pea and oat hay of some of the farmers, or thrashed
as Mr. Wilson finds it profitable to do.

he relief of the labor situation is brought about because the real
ılem for a farmer is not how to get any kind of cheap help, but
to be able to pay for reliable help such as will stay by him and
be trusted to handle live stock. When land yields so much
e than the average that an acre will feed a cow, the return will
for better help than otherwise for two reasons. One is that a
ı in going over 10 acres produces more value in crops, and the
r is that by growing a variety of crops in a rotation the labor is
istributed through the season that rush seasons, such as haying
, with the accompanying high price for extra labor, are done
y with, or at least greatly reduced.

hus the dairyman on the large farm can utilize labor more uni-
ıly and get the yields to pay for it, while the small farmer finds
abor distributed so that he and the other members of his family
handle the work without hiring, as in the case of Mr. Noyes, of
fton County, N. H.

he crops mainly to be depended on in New England for feeding
y cows are corn, three varieties of clover (red, alsike, and mam-
h), oats, field peas, barley, Japanese millet, Hungarian millet,
ter rye, winter wheat, and winter vetch. There may be some
rise that timothy, redtop, and perhaps some other true grasses
not included in the list, but they are intentionally omitted

because they do not furnish so good a quality of hay for dairy co as any one of the other hay crops mentioned.

All the crops named, except corn and Japanese millet, are excell hay crops. From several of the crops either grain or roughage n be obtained, but from them a fine quality of feed is obtained wh the crop is harvested only partly matured. This is a feed that really roughage but which contains so much grain that it is eit richer or more palatable than ordinary hay made from the t grasses. This statement applies to silage made from corn cut wh the ears are glazing, as well as to the small grain when cut for h

Attention is especially called to the ways in which Japanese mil is utilized by several of the farmers already mentioned, as this cr is well adapted to the climate of New England. It should also noted that winter rye furnishes the earliest green feed in the spri for soiling and the earliest hay crop. Further, winter wheat a vetch sown together furnish one of the best milk-producing hay a soiling crops, the second earliest, following closely after rye. Th quality of this mixture of wheat and vetch is such that when it is fe green and then replaced by peas and oats milk production is observe to be materially lessened, although the combination of peas and oat is recognized to be one of the best of green feeds. Wheat and vetc also make a first quality hay if cut when the wheat is in the dough stage.

TABLE III.—*Quantity of seed required and dates of planting and harvesting for the latitude of Concord, N. H.*[a]

Crop.	Quantity of seed per acre.	Date of planting.	Date when fit for soiling.	Date when fit for silage or hay.
Corn	12 quarts	May 18-25	**August 10**	**September 10**
Oats } mixed	1 bushel	April 25 to May 10.	**July 5**	**July 25.**
Peas } mixed	1 bushel			
Barley } mixed	1½ bushels			
Barley	3 bushels	July 1	**September 1**	**September 20**
Winter rye	3 bushels	September 1-20	**May 20**	**June 10.**
Winter wheat } mixed	2 bushels	September 1-20	**June 10**	**July 1-5.**
Winter vetch } mixed	½ bushel			
Japanese millet	30 pounds	June 1-30	**July 5-30**	**August 1-30.**
Hungarian millet	30 pounds	June 1-30	**July 20 to August 20.**	**August 1-30.**
Clover	12 pounds	April 10-30 August 1-25	**June 15**	**June 25-30.**

[a] The dates given are for a normal season. For points to the north or south of Concord or in high altitudes some allowance needs to be made, but the differences will be rather slight.

GENERAL RECOMMENDATIONS.

The methods which are to be generally recommended to dairyme in New England for the producing of feed apply equally to much the State of New York, at least to all the eastern portion of it. The are briefly as follows:

In the first place, all land which can be used at all in such a mann should be kept in a short rotation, not more than three or four or, e most, five years long. This should bring the time which any piece f land is used for hay before replowing down to two or three years at e most. This short rotation gives more clover in the hay, since over is short-lived, only good for two years from the time of seeding, best. The clover not only improves the quality of the hay, but hen hay is grown for three years increases the yield of the hay crop r a year after the clover is gone. If cut for hay only two years the over materially aids the yield of corn or other crop which immedi-ely follows it.

If, as is often the case, a good catch of clover is not easily obtained, e land should be limed, for too much acidity in the soil seems to be e greatest drawback to clover culture in New England. Land laster, wood ashes, or fertilizers containing much potash contribute the same end. The only precaution to be observed is in the case of farm where potatoes are an important crop, for then one must be utious about liming; potato scab may thereby be increased. In at case a fertilizer high in potash, such as is used for potatoes, does uch to improve the clover crop.

When land is such that a short rotation is impracticable, there are rtain precautions to be taken to keep up the yield and quality of hay. he first is, and it is always possible on a dairy farm with a herd of y size, to top dress the grass lands lightly every year. This is the ost important point in the handling of New England permanent ass lands. Aside from this it is advisable to apply to such lands nall amounts of clover seed every year on top of the sod. Both of ese practices are described in detail in the preceding pages. Finally, hether hay be grown in rotation or on permanent grass land, it must cut early if intended for dairy cows.

Some or all of the soiling crops mentioned are frequently desirable fill gaps, and when silage or hay is scarce they may be desirable to ed all summer, along with silage. It should be remembered, how-ver, that the use of a soiling system for the whole season is not, as a le, advisable on account of the labor involved. Wherever it is pos-ble to grow corn the silo should be depended upon, not only for inter feeding but for the entire twelve months in the year in case asture is scarce or poor in quality. It is the cheapest way to get cculent summer feed if the land is at all limited in area or if the astures are not such as to produce good feed in dry weather. In arts of Massachusetts large milk producers consider that it costs 1 nt a quart more to produce milk without silage than with it.

The chief difficulty in growing silage corn in northern New England in getting a suitable variety, and farmers are strongly urged to take vantage of such new varieties of silage corn as may be offered for ial by the agricultural experiment stations of their respective States or by the United States Department of Agriculture, and also to their own seed in order to improve it.

In the most northern sections, such as northern Maine, wher is out of the question and potatoes fill the place of corn in a rot silage can still be made from Japanese millet or other crops an culent winter feed thus provided. Clover and Italian rye-gra successfully used for silage in the State of Washington. This bination is worthy of trial in northern Maine.

It should be noted that all or nearly all of the cropping sy that have been mentioned here are dependent on different vari of one rotation. Several different rotations may compose the sy on any farm, and one rotation may follow another on the same or different fields may be used continuously in different rota The rotations, however, are based on the one so common in localities—that is, corn, small grain, grass. Corn may be replac potatoes, and that is very profitably done in the potato districts the most northern counties of New England, where corn fails. small grain may be left out and the grass (and clover) seeded i corn, or corn may be grown two years instead of one.

The number of years of hay growing may vary from one to five, the small grains may be used as grain or go to supplement and e the supply of hay. Even the rotations for a soiling system are usu based on the same foundation, the crops for soiling coming after c two of them frequently being grown in a year, and then the land back in corn again.

The essentials of the New England dairyman in growing feed his cows appear to be the use of a short rotation wherever possi all the clover hay and corn silage that can be grown; liming the l for clover if need be; better management, especially in the use manure, of land which is not fit for short rotations; and the utili of the various other crops that have been mentioned to fill the g with succulent feed or add in quantity and quality to the ordin hay crop

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MACADAM ROADS.

BY

AUSTIN B. FLETCHER,

Special Agent, Office of Public Roads.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Public Roads,
Washington, D. C., July 15, 1908.

Sir: I have the honor to transmit for your approval a manuscript by Mr. Austin B. Fletcher, secretary of the Massachusetts Highway Commission and special agent of this Office, upon the construction of macadam roads. This manuscript gives in some detail the best practice in macadam road construction. The material contained therein has already been published in Bulletin No. 29 of this Office, but the great increase in the demand for reliable information upon the construction of macadam roads makes the publication of a condensed and revised edition of that bulletin for wide distribution advisable. I respectfully recommend, therefore, that this manuscript be published as a Farmers' Bulletin.

Respectfully,

Logan Waller Page,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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MACADAM ROADS.

INTRODUCTION.

›ulletin is intended as a brief description and discussion of
'al processes and essential features entering into the construc-
macadam roads in rural sections. Some data as to costs,
y for the information of road officials who have not under-
ch work, are included.

etails of construction may require modification to some ex-
e suitable for different parts of the country, depending upon
temperature, and topography, but the general type of road
this bulletin relates is adaptable to nearly all parts of the
States where suitable stone exists or to which such stone may
d without excessive cost.

ord "macadam," as herein used, relates to a surfacing com-
stone broken into small fragments, the largest not exceed-
nches in diameter, suitably bound together into a compact
as to be substantially a sort of concrete, but with no binder
an stone dust or screenings. A road so surfaced might be
operly called a "broken-stone" road.

acadam type of road surfacing is particularly well adapted
highways connecting centers of population, on which there
ate travel. It is not an economical form of pavement for
streets of cities and large towns, and it is usually too ex-
for country roads other than the main highways. It re-
closely a gravel road. When a road built of gravel is not
fficient to resist successfully the wear and tear of the traffic
nacadam surfacing may usually be substituted for the gravel
tisfactory results. Sometimes a macadam surface may be
h economy when the conditions are such that a gravel surface
atisfy the demands of traffic but good gravel can not be
at reasonable cost.

DIMENSIONS OF THE MACADAM SURFACE.

rdinary country roads, experience has shown that the broken-
rface need not be more than from 12 to 15 feet wide, if sh-
ulders are built on each side. Twelve feet allows two vehicles

to pass each other safely. Fifteen feet is more satisfactory, particularly when motor vehicles are passing each other. If the stone is less than 12 feet wide, there is a likelihood that the edges of the macadam will be sheared off by wheels unless the shoulders are made of especially good material. Whatever may be the width of the stone, the shoulders should be firm enough to permit the occasional passage of wheels over them.

Until within comparatively recent years it has been almost universally the practice to build thick macadam roads. Roads less than 8 inches thick were rarely heard of, and often a thickness of at least 12 inches of macadam was thought to be necessary for good results.

The more recent practice is to make the macadam surface as thin as possible, yet with sufficient body to stay in place, the theory being that the macadam is only a wearing surface. By lessening the thickness of the macadam much expense may be saved, since the foundation materials are usually less costly than broken stone. The macadam should be hard, smooth, and impervious to water. Much attention must be given to the foundation. It should be composed of porous material free from clay or loam, firm, and sufficiently strong to sustain any load likely to come upon the road at any time of the year.

In new work, where no macadam has been laid before, 3 inches of macadam after rolling is the least thickness which is practicable; and, except in unusual cases, a depth greater than 6 inches after rolling is rarely necessary if the foundation is suitable.

The ordinary macadam road is usually from 12 to 16 feet wide, with shoulders 3 to 5 feet in width on each side of the broken stone. The thickness of the macadam is usually 6 inches at the center and 4 inches at the sides, or a uniform depth of 6 inches throughout.

STONE FOR MACADAM ROADS.

KIND AND QUALITY.

The principal qualities which are necessary in road-building stones are hardness and toughness. The cementing values of the stone dust should not be forgotten, but these are not so important as the qualities first mentioned. Often the choice of stone is very limited. It may be that only field stones may be had, or perhaps nothing but inferior ledge stone can be found, except at a prohibitive cost.

Trap rock—meaning by the term the diabases, the diorites, and certain other igneous rocks—has long been considered the best material for macadam purposes. Unfortunately, except in certain localities, these stones are not common. Some of the hornblendic granites give good results, as do the felsites and some of the harder limestones.

The slates, schists, most of the sandstones, the micaceous granites, and the quartzites have but little value as road-surfacing material. Often these stones may be used economically in the lower course of the macadam, provided the upper stratum is composed of a better grade of stone. But road officials should avoid the selection or rejection of stones because of their names alone. Some large-crystalled granites and some of the limestones are of very little value, and, on the other hand, there have been instances where certain schistose rocks have been used with excellent results. Stone from a ledge, because of its uniformity in desirable qualities, is usually better than field stone and makes a smoother and more durable road; but if the ledge is of an inferior grade of rock, it should not be used, merely because it is ledge, in preference to field stones of a better quality of rock.

At the present time there should be no difficulty in determining the relative values of stones for road purposes in any locality. The Office of Public Roads, of the United States Department of Agriculture, now undertakes to make tests and analyses of samples of stones, without charge, and to give advice as to their value for road-building purposes.

THE WEIGHT OF BROKEN STONE.

When broken stone is bought from a manufacturing company and shipped by rail, or otherwise, it is frequently sold by weight. Before estimating the cost of a road when the stone is to be paid for by weight, the road official must know how much the stone will weigh per cubic yard. To dispel the somewhat general impression that all stone weighs the same per unit of volume and that a cubic yard of broken stone always weighs a ton and one-third, the specific gravity and weight of a number of different kinds of rock are given in Table 1. The table is from data recently published by the Office of Public Roads.

TABLE 1.—*Specific gravity and weight of various rocks.*

Number of samples tested.	Name	Specific gravity.			Weight per cubic foot of solid rock.			Weight[a] per cubic yard of solid rock.		
		Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.
					Pounds.	*Pounds.*	*Pounds.*	*Tons.*	*Tons.*	*Tons.*
3	Peridotite (trap)	3.55	3.25	3.40	221	203	212	2.984	2.741	2.862
124	Diabase (trap)	3.20	2.60	2.95	200	162	184	2.700	2.187	2.484
33	Diorite (trap)	3.35	2.70	2.85	209	168	178	2.821	2.268	2.403
60	Schist	3.20	2.65	2.90	200	165	181	2.700	2.227	2.443
11	Felsite	2.80	2.50	2.65	175	156	165	2.362	2.106	2.227
53	Quartzite	3.10	2.50	2.70	193	156	168	2.605	2.106	2.268
358	Limestone	3.10	2.00	2.65	193	125	165	2.605	1.687	2.227
106	Granite	3.00	2.00	2.65	187	125	165	2.524	1.687	2.227

[a] Tons of 2,000 pounds.

In Table 1 the weights are of solid rock. If it be assumed that the volume of the stone after it is crushed and as it lies in the bins has

50 per cent of voids, and the average weight of peridotite is compared with the average weight of granite, it will be seen that crushed peridotite weighs 1.43 tons to the cubic yard, while the granite weighs only 1.11 tons. The heaviest diorite weighs 1.41 tons to the cubic yard and the lightest only 1.13 tons. Differences as marked as these will be found in the different stones referred to in the table.

After broken stone has been carried for some distance on the cars or in carts it packs, and a given weight will not occupy so much space as before it began its journey. In contracting for stone by the cubic yard the place of measurement should always be agreed upon in advance.

In Massachusetts the State highways are all built by contract. All of the broken stone used in the macadam work is weighed, so that the weight of the stone in all of the roads is a matter of record. In fact, it might almost be said that the roads there are built by weight rather than by measurement. (See page 22.)

On the roads built in Massachusetts in 1906 the imported stone—in all cases trap rock—covered 3.13 square yards of surface to the ton of 2,000 pounds where it was intended to average 5 inches in depth after rolling.[a] Where a thickness of 4 inches throughout the cross section was employed a ton covered 3.76 square yards. The local stone, which consisted mostly of field stones and was usually some variety of granite and of less weight per unit of volume than the trap, covered in the 5-inch sections 3.32 square yards and in the 4-inch sections 4.03 square yards.

TOOLS AND MACHINERY.

STONE-CRUSHING OUTFITS.

In addition to the shovels, picks, and other ordinary implements, a considerable outlay for machinery is necessary. In these days of high-paid labor and short working hours one rarely hears in this country of macadam stone being broken by hand.

There are many kinds of stone crushers on the market. Except for city use and in cases where a large amount of macadam work is done every year within a comparatively small area, large stationary plants are undesirable. There are several kinds of portable plants which may be bought at prices ranging from $1,600 to $2,500, which are admirably adapted for country use. These plants include the stone crusher, engine and boiler, portable bins, revolving screen, and an elevator to lift the stone after it is broken and to discharge it into the screen.

---

[a] Six inches thick at the center and 4 inches thick at the sides.

The outfits are mounted on wheels and may be moved from place to place at a comparatively small cost. Under ordinary conditions from $50 to $100 will pay the expense of shifting such a plant from its old location to a new one several miles distant.

Stone crushers are variable in their outputs. They all need much repair work from time to time, on account of the severe usage to which they are subjected. With an outfit such as has been mentioned, from 80 to 100 tons (60 to 80 cubic yards) of broken stone per day may be reasonably expected if the plant is kept in good condition. Such an output is usually satisfactory, since a single steam road roller will not often roll more than this amount in a day. The crusher will take stones which measure up to approximately 7 by 14 inches in cross section; larger stones require mauling before they can be placed in the receiving orifice.

In some places it may be found more economical to have the stone shipped in from some permanent crushing plant than to purchase a crushing outfit, and it is well to consider this feature carefully. It should also be stated that while the first cost of the road is important, the costs of future maintenance must also be taken into account. It is sometimes economical, even at a greater initial cost, to import stone from a distance, if thereby a more durable road may be had than is possible by the use of local stone.

In places where the stone supply is limited to ledges at infrequent intervals, there is often but little choice as to the location of the crushing plant. It is as easy to haul the broken stone to the road if the crusher is set up at the ledge as it is to haul the unbroken stone from the ledge to the crusher if set up beside the road. But if field stones are to be used or suitable ledges are available along the road to be constructed the crusher should be located near the road. Experience has shown that 2 miles of road is about the economical limit for operating the plant in one place. If a greater length of road is to be built it is usually cheaper to move the plant than to haul its product a longer distance.

The plant should be set up as nearly as practicable in the center of the section to be built; but since much water is needed for the boiler, for the roller, and for the watering cart, the crusher site is often governed by the location of the water supply.

If possible the crusher should be set low enough so that a platform may be built at the level of the opening which receives the stone. This platform should be sufficiently strong to bear the weight of the carts loaded with stone for the crusher. With this arrangement the large stones may be dumped upon the platform and fed into the crusher without further lifting.

The workmen who set up the plant should have had experience in this work. Much depends on the proper alignment of the several parts, and many petty annoyances in operation will be avoided if the work is done properly in the first instance.

ROLLERS.

The steam road roller is now used to so great an extent that a discussion of its advantages over the horse roller is unnecessary. Macadam roads may, of course, be built with rollers drawn by horses; they may also be built without any rolling except by the wheels of moving vehicles. But experience has demonstrated that quicker and better work can be done with the steam roller, and usually at a less cost. A so-called "10-ton roller" is sufficiently heavy for country roads. Most of the culverts and many of the bridges are too weak to sustain, with safety, the heavier rollers. There are several excellent makes of such rollers, which may be had at prices ranging from $2,500 to $3,500.

WATERING CARTS.

Since water is always needed in rolling the macadam, a watering cart or sprinkler should be provided. The road official can not often afford to wait for rain. A cart with a capacity of 450 to 600 gallons will be sufficient. Most of these carts are provided with extremely broad tires, so that the cart assists in consolidating the stone, instead of rutting it. Many communities are provided with one or more watering carts, so that it is often unnecessary to purchase a new one for road building.

ROAD MACHINES.

Many road officials have a road machine which they can use. This is a most serviceable implement when used properly. Often it is misused in repairing earth roads. The practice of scraping back upon the road worn-out material which has been washed into the gutters can not be too heartily condemned. The road machine can be used to advantage in preparing the road for the broken stone. Drag and wheel scrapers are useful in grading and shaping the roadbed. Automatic spreading carts of several different kinds are often used in spreading the broken stone. They are useful and save considerable time and labor, but are not essential.

LABOR AND TEAMS.

In macadam work, as in all other construction work, there should be a competent foreman or superintendent in charge.

Since no two pieces of road are ever alike, no definite statement can be made as to the number of men required for the grading and other details, except with regard to the broken-stone portion of the work, and the same is true with regard to teams. The foreman has an opportunity to use considerable judgment and skill in arranging his men and teams so as to secure a maximum of effect with a minimum of effort.

Not many laborers are required to take care of the output of a single crushing plant. The crusher engineer and the roller operator should be skilled mechanics. Both of these men act as firemen, and, in fact, usually take entire care of the machinery under their charge. Two ordinary laborers are usually enough to feed the crusher, with a third man to assist them occasionally and to maul stones which are too large for the receiving orifice. Two spreaders are needed to take care of the broken stone as it is delivered on the road, and a driver and a pair of horses are required for the watering cart. It is impossible to give the number of teams needed for the broken stone, since the number is dependent almost wholly on the length of haul.

To show how the number may be ascertained in a specific case, the following example is given: Assuming that the average length of haul from the crusher to the point of delivery on the road under construction is 1 mile; that the route of haul offers no unusual difficulty in grade or surface; that 100 tons (about 80 cubic yards) of broken stone per day is to be hauled to the road; and that 2 tons are to be carried in each 2-horse load; then one team to do the work would have to make 50 trips of 2 miles each, or, in other words, it would have to travel 100 miles per day. Since a pair of horses engaged in this kind of work will not average more than 20 miles a day for many consecutive days, under the conditions assumed, five teams would be necessary.

If the crusher is set up at a ledge there will be no teaming to it, but if field stones are to be crushed, the hauling of these stones to the crusher must be considered also, unless, as frequently happens, farmers haul the stones from their own land and deliver them at the crusher at prices agreed upon.

In quarrying ledge stone, the number of laborers depends largely on the character of the stone, and each case must be considered by itself.

EARTHWORK.

A civil engineer should lay out the work, establish the grades, and set the grade stakes. Often in rebuilding an existing road it is advisable to change the grades to a considerable extent, and then the services of a civil engineer are likewise required.

Theoretically, the grades should be as nearly level as possible, but in most localities this ideal condition can not be realized, nor will the available appropriation usually permit even an approach to the maximum grades adopted by the railroads. Practically, in road construction little is ordinarily done beyond reducing the hills to the maximum grade which has been adopted and in removing the irregularities between the hills. If suitable, the materials excavated from the hills are used in filling the depressions.

It is obvious that the subgrade or foundation is the part of the road most nearly permanent. No matter what surfacing material is used, it will eventually wear out and require renewal. The grades, therefore, should be most carefully studied, since after the macadam surface is completed they can not be changed without great expense.

In American practice the maximum grade for important roads has been generally fixed at 5 per cent where such a grade can be had without too great expense for grading and for damage to abutting property. By 5 per cent is meant a vertical rise of 5 feet in 100 feet of horizontal distance. A horse can trot without especial difficulty up such a grade. On steeper grades, macadam surfaces, or, indeed, any kind of a surface, can be maintained only at considerable cost.

Some authorities insist that a macadam road should never be level, arguing that a slight rise and fall is needed to permit the surface water to run longitudinally along the road. Usually, even if the road is absolutely level, if it is also properly crowned, the gutters of the road may be so graded as to provide suitably for surface drainage. The width of the grading will depend, of course, on the width of the macadam adopted.

In fixing the grades care must be taken to adjust the cuts and fills so that there will be little or no waste of material. This requires some judgment and experience, since most materials shrink to a greater or less extent when taken from the cuts and placed in the fills. It is estimated that this shrinkage, together with certain unavoidable waste, averages about 15 per cent. When the depth of the fill is but a few inches, the use of the steam roller will often cause a much greater shrinkage.

A line of grade stakes should be set on each side of the roadway. These stakes should be not more than 50 feet apart and the established grade should be plainly marked on them. They should be set sufficiently far from the roadway not to be disturbed by the grading and other operations. These stakes will serve later for the macadam work.

The road should be graded to the approximate subgrade elevation with a sufficient surplus of material to form the shoulders. It should also be remembered that the materials will settle to a considerable extent when the steam roller is brought on.

The surface water should always have opportunity to drain from the roadway as quickly as possible, and the gutter grades should be so fixed that there will be at least 6 inches fall in 100 feet. With a less fall, if there be snow in the winter, the water will be held back and cause trouble. Deep ditches beside the road are dangerous to travelers and are usually unnecessary. It is a better practice to construct culverts more frequently and to lay pipes longitudinally under the road connected with catch basins and leading to suitable outlets.

No impervious materials, such as clay and loam, should be permitted within at least 18 inches of the top of the completed road, particularly if it is in a locality where the ground freezes in winter. All stumps and roots should be grubbed out and removed. The clay and loam may be placed on the sides of the road, but such materials should not be permitted under the broken stone. Sand, gravel, or other material which does not hold water should replace them.

DRAINAGE.

SUBSURFACE DRAINAGE.

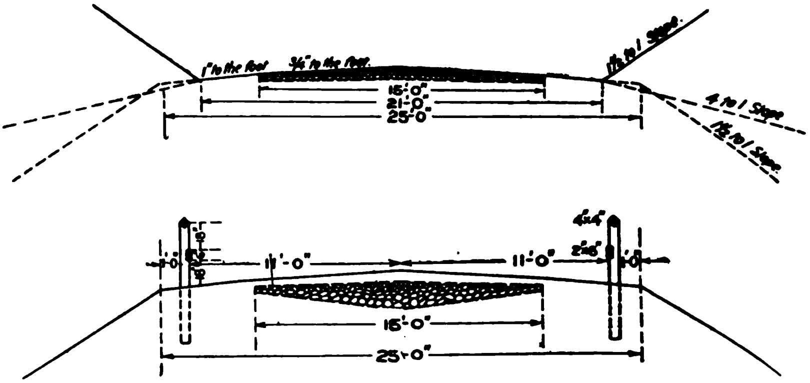
Water should never be permitted to remain under a macadam road. It softens the foundation so that the broken stone is forced down into it by the wheels of vehicles, thus causing ruts to develop in the macadam. In freezing it expands and "heaves" the broken stone, destroying the bond and causing the larger fragments of stone to rise to the surface. As a result the material in the subgrade is forced up into the interstices, and in the spring the macadam will be found to be rough, irregular in shape, and weakened. There are several ways of removing the subsurface water, at least in part. Sometimes if the grade is raised in wet places the trouble will be lessened, particularly if porous materials are used.

Side Drains.

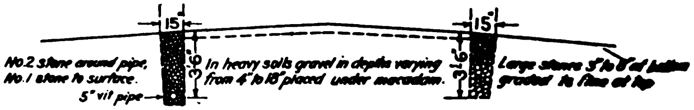
Side drains may be constructed in the cuts on each side of the road, just outside of the limits of the macadam. (See fig. 1, bottom.) These drains consist of narrow trenches, filled with broken stone or small gravel stones, with a pipe 5 or 6 inches in diameter near the bottom. The pipe is laid with open joints, true to grade, and is carried to a proper outlet. Sometimes the pipe is omitted and the entire trench is filled with stones, in which case it is called a blind drain. Such drains serve to cut off the subsurface water before it can get under the macadam.

V Drains.

The subgrade may be excavated to the width of the macadam so as to be 6 to 8 inches deep at the edges, and 12 to 18 inches deep at the center. The surface will then have the shape of an extremely flattened letter V. (See fig. 1, middle.) The bottom should be fairly true to grade, so as to permit the water to flow readily. This excavation is filled with stones varying in size from small pebbles to boulders 8 or 10 inches in diameter, the largest being placed at the bottom. These stones need not be placed with special care, but the condition of the mass should be such as to permit consolidation with a roller. To dispose of the water collected by a drain of this kind, narrow trenches should be cut to the sides so as to connect with open outlets. These trenches should also be filled with stones. Such a drain is usually effective and ordinarily costs less than two side drains.



V UNDERDRAIN.
Cobble-filled: large stones at bottom; small stones and gravel at top.


15
15
No. 2 stone around pipe,
No. 1 stone to surface.
5" vit pipe
In heavy soils gravel in depths varying
from 4" to 18" placed under macadam.
Large stones 5" to 8" at bottom
graded to fine at top

SIDE DRAIN. BLIND DRAIN.

FIG. 1.—Typical cross sections of macadam roads.

Telford Foundations.

Another way of nullifying in part the effect of the subsurface water is to construct a foundation of telford. Formerly, nearly all macadam roads were built with a telford base, regardless of any consideration of the requirements of traffic. It is now generally recognized that, except in unusual cases where the subsoil is full of water which can not be drained out, the telford base is unnecessary except for purposes of subdrainage. A satisfactory telford foundation may be made by placing vertically on a layer of gravel 2 or more inches in depth, stones of fairly uniform size, not exceeding 10 inches in width, 6 inches in depth, and varying in length from 6 to 20 inches. The stones should be set on their broadest edges, lengthwise across the road, and wedged rigidly into position by driving smaller stones into the interstices with mauls. Projecting points should be broken off with stone hammers, depressions filled with chips, and the telford rolled with a steam roller until it is true to the desired cross section.

Where the foundation of the road would otherwise be very bad, and no gravel or other like material is readily obtainable, or where an unusually substantial road is required to meet the demands of traffic, this form of construction is recommended. Under ordinary conditions it is much too expensive. It has been said, and there is some supporting evidence, that a rigid and unyielding telford base has the effect of an anvil, and that the macadam, under the pound of traffic, wears more rapidly than in the ordinary broken-stone road.

Several other devices are sometimes employed to take care of the subsurface water, such as the center box drain, built of slabs of stone, and side drains, with plank boxes in lieu of drain tile. Usually these are either too expensive or of too unstable a nature to be recommended.

SURFACE DRAINAGE.

The removal of surface water has already been discussed to some extent under the subject of "earthwork" (pp. 12, 13).

It is obvious that the water which falls on the road and which flows upon it from adjacent lands should be got rid of as soon as possible. Culverts should be built at low points where outlets are available, and existing streams should always be utilized for outlets. The water should never be carried in the gutters or in side ditches any farther than is necessary. When the volume of water is small, it may often be carried across the road in tile pipes buried sufficiently deep not to be broken by vehicles upon the road. If it is necessary to lay a pipe within 2 feet of the surface of the roadway, iron water pipe or gas pipe should be used. For larger volumes of water culverts of rubble masonry or Portland-cement concrete may be built. Very often it will be found to be more economical to use the concrete, particularly if it is reinforced with steel.

Large culverts and bridges should always be designed by competent civil engineers and constructed under their supervision. Indeed, very often the advice of such an engineer in regard to the smaller waterways might be sought with profit. Money is too often wasted from a lack of knowledge concerning the proper sizes of pipes and culverts.

In many localities it is the custom to have the main road and driveways from adjacent lands intersect at the same center grade. This practice makes it necessary to carry the gutter water under the driveway in a pipe. Nearly always it is possible, by regrading such a driveway, to make it coincide with the gutter grade, so that the surface water will flow by without interruption. This should always be done when possible. Pipes with open ends laid at the gutter grade are always unsatisfactory, since they fill up quickly with leaves and sand and with slush in winter time, and thus the surface water is forced out upon the macadam and soon gullies it. When a pipe is required, a catch basin should be built on the upper side of the driveway, the pipe should be laid to connect with it, and carried sufficiently far underground to discharge properly into the gutter below the driveway.

In cuts where the grade is in excess of 3 per cent and where the soil is loose or sandy it is sometimes necessary to pave the gutters with cobblestones or with paving bricks or paving blocks to prevent the formation of gullies in the shoulders and in the macadam. Usually a gutter 3 feet in width laid on the same or a little greater slope than the macadam, with an outer row of large stones about 1 foot high laid vertically against the bank of the cut, is sufficient. Such a gutter usually replaces the shoulder, and it should not be constructed until after the macadam is substantially completed.

SHAPING THE SUBGRADE.

It is not enough that the roadway shall be graded with reasonable care. The surface upon which the broken stone is to be placed must be hard, smooth, and carefully crowned. If the foundation is not hard and firm the stones will be pressed into it by the roller and wasted. If not crowned, an unnecessary quantity of stone will be used. When the macadam is to be of uniform thickness throughout its cross section, the crown of the subgrade should be the same as that of the finished road. If the macadam is to be thicker at the center than at the sides, a part of the crown will be in the macadam itself and the center of the subgrade should be raised enough to produce the contemplated surface crown when the stone is in place. In shaping the subgrade, a road machine can generally be used to advantage.

Usually sufficient material is left on the sides to form the shoulders for the macadam. If the natural soil is not sufficiently good for shoulders, suitable material should be brought on at this time. The shoulders, in addition to affording a surface for the occasional passage of wheels, serve to some extent to prevent crowding the broken stone outside the limits of the proposed macadam roadway during the rolling.

After the roadbed is shaped to the approximate cross section it should be rolled thoroughly until it is hard, firm, and smooth. This is essential, since if the subgrade is soft much of the broken stone will become embedded in it later. If soft places are found or depressions develop during the rolling, more good material should be put on so that when the subgrade is ready for the broken stone it shall conform to the proposed cross section as nearly as practicable.

THE COURSES OF MACADAM.

SIZES OF STONE.

All modern crushing plants are equipped with revolving screens to separate the broken stone into sizes, and after passing through the holes of the screen the stones fall into their appropriate bins. The "tailings," or stones which are too large to pass through the holes in the screen, run out at the lower end upon a conveyor, which carries them back to the mouth of the crusher to be broken again.

Usually there are three sections in the screen; the first, nearest the higher end, has holes sufficiently large to allow fragments not exceeding one-half inch in diameter to pass through. The holes in the second section permit stones 1¼ inches in diameter to pass through, and those in the third section allow stones 2½ inches in diameter to pass through. All larger stones are forced out at the open end of the screen, where they drop upon the "tailings" conveyor.

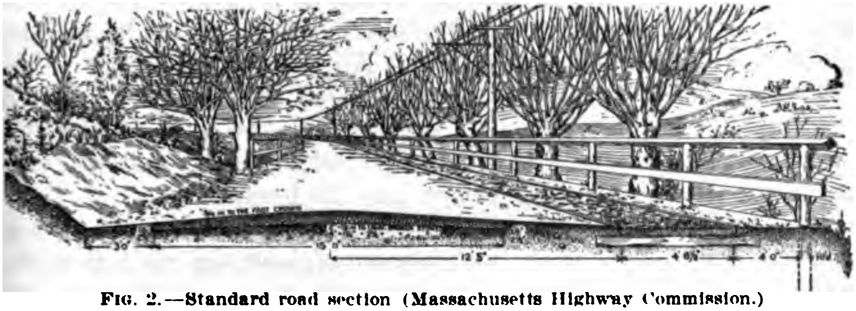


FIG. 2.—Standard road section (Massachusetts Highway Commission.)

A stone 2½ inches in diameter is as large as should be used in macadam work. Usually fragments of this size are used in the lower or first course. Those of the 1¼-inch size are used in the upper course. If the stone is hard, this size is about as large as can be used to give a smooth surface. Soft stone will often crush under the roller, and, where such stone is used, sizes larger than 1¼ inches may sometimes be used with good results.

The jaws of the crusher should be set so as to make as few "tailings" as possible, and the lengths of the screen sections should also be properly adjusted to the same purpose.

CROWN.

Every macadam road should be crowned, in order that the water falling upon it may run quickly to the gutters. It is also necessary that the shoulders should have the same slope as the macadam or perhaps a little greater. (See fig. 2.)

For a road 15 feet or less in width it will be found satisfactory to have the center 5½ inches higher than the sides, forming a crown of three-quarters of an inch to the foot. On roads of greater width it will be necessary to reduce the crown to one-half inch to the foot, or perhaps even less. The apex should be slightly rounded.

THICKNESS OF COURSES.

Since the wear at the center of the roadway is always greater than at the sides, some saving in stone may be made by reducing the thickness at the outer edges. A layer of loose stones more than 6 inches deep can not be compacted with a roller easily, if at all, and modern roads are all built in two or more layers or courses.

To secure smoothness and even wearing, the smaller sizes of stone should be placed in the upper course and the larger in the lower. When a road is built with the sizes mixed, unless the stone is unusually soft, a rough surface inevitably results in a comparatively short time after the road is opened to travel.

When broken stone is spread loosely, as on a roadway before it is rolled, the voids aggregate between 40 and 50 per cent of the volume of the layer or course. The roller passing back and forth over the course consolidates the material and a large percentage of the voids, often from 30 to 40 per cent, is eliminated. To secure a finished roadway 6 inches thick, about 8½ inches of loose stone, not reckoning the binder, is necessary. This is in part due to the unavoidable forcing of the stones, to a slight extent, into the foundation.

In the State road work in Massachusetts it is recognized that a uniform depth of stone on the roads throughout the State is undesirable, because of differences in local conditions. Table 2 shows the courses and total thickness of stone most commonly applied in that State. The last two are rarely used except in resurfacing a worn-out macadam road.

TABLE 2.—*Thickness of courses of macadam.*

Lower course.		Upper course.		Total thickness.	
Center.	Sides.	Center.	Sides.	Center.	Sides.
Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
4	2½	2	1½	6	4
2½	2½	1½	1½	4	4
4	(a)	2	1½	6	2½
2½	(a)	1½	1½	4	2½

[a] The stone is spread as thinly as possible.

The binder or "matrix," as it is sometimes called, consisting of the stone dust and small fragments of stone which pass through the ½-inch holes in the screen, is not counted as a course. No more of the binder should be used than is necessary to fill the voids and just cover the upper course of stone.

In Massachusetts no stone dust is applied until after the two courses of stone are rolled thoroughly. Then a thin layer of the screenings is spread, the watering cart is brought on, and the "fines" are flushed down into the interstices. It is rarely necessary to use, altogether, more than 1 inch in depth of the screenings. This method has been followed for a dozen years with complete success.

Under ordinary conditions, no clay, loam, or other like material is needed, either in the interstices or on the surface, to keep the road from "raveling." In very dry and hot climates, and where the roads are subjected to the ravages of motor vehicles operated at excessive speed, it may be necessary to apply some special binder and dust preventive, such as tar or asphalt oil, and for such places these materials are recommended in place of the clay and loam sometimes used and called "packing."

Sometimes binder, consisting of stone dust, sand, and even clay or loam, is worked into the first course during the rolling of that course. It is difficult to see how this practice adds in any way to the integrity of the road. It is true that considerable rolling is saved by this method, and, also, that once in a while, when it is not possible to secure a firm foundation or when extremely hard stone is used, some binder may be needed to keep the lower course in place so that it may be rolled. The use of clay should always be avoided.

PLACING THE BROKEN STONE.

As soon as the drainage work is completed and the roadway has been graded, shaped, and rolled for a few hundred feet, the spreading of the broken stone should be commenced.

Lower Course.

As stated before, the larger sizes of stone, ranging in diameter from 1¼ to 2½ inches, should be spread first. The stone should never be dumped from the carts directly upon the road. When broken stone or gravel is dumped from the ordinary cart it falls in a pile with the smaller fragments consolidated to a greater or less extent in the center of the heap. When the pile is leveled subsequently the core remains almost intact. An uneven road usually results, and often the individual loads may be counted after the road has been in use for some time. Unless automatic spreading wagons are used, the stone should be shoveled from the carts or dumped on a movable platform of planks about 6 feet long and 3 feet wide, sometimes called a "dumping board." The spreaders should then shovel the

stone from this platform upon the prepared subgrade to the requir
depth for the lower course, remembering, as before stated, that th
course will shrink in depth approximately 35 per cent under th
roller. The depth of the course should be tested frequently by strin
stretched across between the stakes. Sometimes blocks of wood
the required height are set on the subgrade and the stone is spre
until the top of the course is flush with the tops of the blocks. T
stone is frequently leveled with rakes.

When a hundred feet or so of the first course has been spread, t
rolling should begin. It will be found best to begin the rolling
the outer edge of the macadam, running upon the shoulder a fe
inches. When this portion of the stone ceases to wave and see
firm under the foot, the roller should be moved to the other side
the roadway and the operation repeated there. After both sides
the roadway are moderately firm, the roller should be moved grad
ally toward the center until the entire lower course is thorough
compacted.

Sometimes it is found that the wavy motion continues and that t
stones will not compact. This may be due to a wet subgrade, whic
if allowed a day or two to dry out, will give no further trouble,
it may be due to the use of an excessively hard stone, in which ca
the application of a little sand or fine gravel may remedy the dif
culty. With some soft, coarse, gravel stones, a "crawling" moti
may be noticed. In this event, instead of compacting, the shar
corners of the stones become rounded. If the rolling is continue
the stones become like marbles. A slight sprinkling of coarse san
stone screenings, or, in some instances, the application of water, ma
prevent this action. It must not be expected that the lower cour
will be absolutely rigid. If it is rolled enough to prevent the ston
from shaking when one walks over them it is sufficient.

If depressions develop as a result of the rolling, additional sto
of the same size as used in the course should be added and rolled, a
before the second course is put on the lower course should be smoo
and true to the cross section.

Upper Course.

After about 100 feet of the first course of stone is rolled, t
second course, consisting of the fragments varying in diameter
tween one-half inch and 1¼ inches should be spread from the dum
ing board and rolled in the same manner as was the lower cour
After this course is thoroughly compacted, the binder should
spread. Usually but little more than 1 inch in depth of the scre
ings is required in 6-inch work. The watering cart should then
put on in advance of the roller and as much as possible of the d

should be flushed into the crevices between the stones. The roadway should be wet and rolled until it "puddles" on the surface, showing that the voids are substantially filled.

No more of the screenings should be used than is necessary to fill the voids and to leave a very thin covering over the larger stones. Depressions in the upper course should not be filled with screenings, but rather with stone of the size used in that course.

The ability of the roller operator is a very important factor in macadam work. The appearance of the road surface depends to a great extent on his skill.

No matter how much the macadam may be rolled, it will not acquire the metallic ring usually noticeable in roads of this kind for some days. The calks of the horses' shoes will roughen the surface for a short time, and it is a good plan to keep the roller on the completed road moving back and forth during the progress of the work whenever it is possible.

It is well not to allow the lower course to be spread too far in advance of the upper, and to put on the screenings and water and roll them as soon as possible after the upper course is rolled. There is of necessity more or less teaming over the road during its construction, and while the courses are in an uncompacted condition the horses' hoofs and the wheels of vehicles are detrimental to the work; but when the macadam is completed the sooner it is used the better.

THE ROADSIDES.

No matter how smooth and well constructed the traveled road may be, if the roadsides are not cared for, the highway as a whole will not give a good impression. All rubbish should be removed; the excavations should be filled and embankments smoothed and planted with grass wherever it will grow. Unsightly brush should be cut and grubbed out. Sometimes, however, the brush and small trees, if suitably trimmed, add to the attractiveness of the roadside.

All trees that are ornamental or which have value as shade trees should be preserved and protected, unless they grow so close together as to make a dense shade. In hot, dry climates particularly, and, indeed, in most places, trees are a considerable factor in reducing the cost of maintenance, since they lessen the evaporation of the moisture from the macadam. In exposed places where the sweep of the wind would be otherwise unbroken they serve to prevent in a measure the blowing away of the binder from the road surface. Unfortunately in such places it is often difficult to make trees grow. Care in the selection of the kinds of trees best suited to the locality

In Massachusetts, sugar, Norway, and white maples and American elms have been set out to a considerable extent along the State roads with satisfactory results. These trees grow fast and at the same time are fairly long-lived.

A good arrangement along roadsides for trees with large tops is to set them about 50 feet apart on each side, but alternating so that there will be a tree every 25 feet along the road.

THE COST OF MACADAM SURFACES.

Comparison of average costs of roads in one locality with those in another is of little value, for the reason that the conditions in two localities are never precisely similar, and but rarely even approximately alike. Particularly is this true of such details as earthwork and drainage. Even the costs of broken-stone surfacing often lead to wrong conclusions. There are too many factors which are dependent on local conditions. With this caution, certain cost data of macadam work alone are given in Tables 3 and 4. The data are from records of State work in Massachusetts and New Jersey. In each case the measurements and costs are of the stone in place and rolled, and the lengths and costs are estimated upon the basis of a roadway 15 feet in width. They relate to the macadam work alone and do not include the expenses of grading, drainage, or any other incidental items.

TABLE 3.—*Average costs of macadam work in Massachusetts in 1906.*

Source.	Depth of stone at center.	Depth of stone at sides.	Length of road built.	Cost per mile.	Cost per square yard.	Cost of stone per ton (2,000 pounds).
	Inches.	*Inches.*	*Miles.*	*Dollars.*	*Dollars.*	*Dollars.*
Imported stone (trap rock)	6	4	8.25	5,496	0.6245	[illegible]
	4	4	6.97	4,746	.5393	[illegible]
Local stone	6	4	21.74	3,696	.4201	[illegible]
	4	4	6.56	3,459	.3931	[illegible]

TABLE 4.—*Average costs of macadam work in New Jersey in 1905.*[a]

Depth of stone.	Length of road built.	Cost per mile.	Cost per square yard.
Inches.	*Miles.*	*Dollars.*	*Dollars.*
4	6.441	2,148	0.2422
5	1.772	3,652	.4150
6	7.129	5,687	.6299
8	21.748	6,187	.6958

[a] Report of the commissioner of public roads of New Jersey for 1905.

Further details of the cost of both Massachusetts and New Jersey work are given on pages 33 to 36.

In New Jersey the work appears to be done at a somewhat less cost than in Massachusetts. This may be due in part to the fact that longer stretches are built in one section in New Jersey. Possibly the per diem rates of pay for labor are smaller there and the hours of labor not so restricted. Road officials in that State are advised to use 2,461 tons of broken stone, exclusive of the screenings, to the mile of road 15 feet wide and 6 inches in thickness after thorough rolling.[a] The screenings needed are estimated to weigh 407 tons to the mile, making a total weight of 2,868 tons. Trap rock is used almost exclusively in New Jersey. In Massachusetts in 1906 the 6-inch-4-inch roads (average depth, 5 inches), built of trap rock and 15 feet wide, averaged 2,810 tons to the mile, including the screenings. It would appear from these figures that in Massachusetts nearly as much stone is used in building the 5-inch roads as is required in New Jersey for 6-inch work.

In Massachusetts, as previously stated, all the roads are built by contract. In some few instances the towns contract with the State board to do the work. In most cases the work is let to the lowest bidder, after advertisement and public opening of bids. In all cases the contracts are made on the unit basis—i. e., the contractor is paid a price agreed upon for each cubic yard of earth moved, for each cubic yard of ledge excavated, for each ton of broken stone laid in place in the road, etc. This method naturally entails much measuring of volumes by the engineers and considerable expense, but it lessens the speculative risk taken by the contractors in bidding on the work, allowing them to make their bids on the lowest basis. The practice surely has the merit of being eminently fair to both parties to the contract. Unless the broken stone is shipped to the work by rail, scales are set up by the contractor near the road, and all stone going upon the road is weighed. The contractor pays for the scales, the State for the weigher. The contractor has no incentive to skimp his work, since he knows in advance that he will be paid for all of the work which he does and for all of the materials which he supplies.

For several years past no actual cost data have been kept of the Massachusetts roads, except in some few special cases. A mass of such records was secured in the early work of the highway commission, and, using the old records, it is possible, without essential error, to analyze the present costs of macadam work.

Two cases will be considered, namely, the average cost of surfacing with imported stone and the average cost with local stone, the consolidated macadam being in both cases 6 inches deep in the center and 4 inches at the sides, or an average of 5 inches. In this analysis of costs of broken stone in place, the macadam surface only is considered. The figures do not include any of the expenses of grading, draining, or other incidental work. In 1906 the cost to the State of the imported stone in place averaged $1.96 per ton. It is fair to assume that the contractor's profit was 15 per cent, on the average, and deducting this, $1.70 is left as the probable actual cost of the stone in place. This is made up, approximately, as shown in Table 5.

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[a] Report of the commissioner of public roads of New Jersey, 1905, pp. 161-162.

TABLE 5.—*Actual cost of imported stone in place.*

Item of cost.	Per ton.	Per square yard of completed road.
Cost of stone on railroad siding nearest the road	$1.15	$0.368
Unloading stone from cars	.07	.022
Hauling from cars to road	.25	.080
Spreading stone	.05	.016
Watering stone	.06	.019
Rolling stone	.12	.038
Total	1.70	.543

The local stone in place cost the State, on the average, $1.40 per ton. Assuming the same average profit to the contractors as before, the actual cost of the work was $1.22 per ton. This is made up, substantially, as shown in Table 6.

TABLE 6.—*Actual cost of local stone in place.*

Item of cost.	Per ton.	Per square yard of completed road.
Cost of stone at crusher	$0.50	$0.151
Breaking stone	.25	.075
Hauling stone to the road	.25	.075
Spreading stone	.05	.015
Watering stone	.05	.015
Rolling stone	.12	.036
Total	1.22	.367

In considering the Massachusetts costs it should be borne in mind that labor there is high and that the hours of labor per day are short. The nine-hour labor law applied to most of the work discussed above, and during the latter part of the year 1906 the eight-hour law was in effect.

Following is a schedule of the average wages per day of the laborers, workmen, and mechanics which prevailed in the year 1906, together with the prices paid for teams:

Ordinary labor	$1.75 to $2.00
Crusher and roller engineers	3.00 to 3.50
Foreman	3.00 to 5.00
One-horse wagon, including driver	3.00 to 4.00
Two-horse wagon, including driver	4.50 to 5.50

In public works some of the elements entering into the actual costs are not usually considered. At least they are usually not included [illegible] the costs as reported. The salary of the road official who directs the work is usually omitted. Some other items are the interest charges on the capital invested in machinery, teams, tools, etc., the costs of repair of such appliances, and the provision for renewing the same when worn out and no longer useful, sometimes called the amortization costs. It is fair to assume that the private contractors, or most of them, take these items into consideration in bidding on the work.

Enough has been stated in the foregoing to indicate that macadam roads when properly built cost a considerable sum per mile, particularly when it is remembered that the cost of grading, drainage, etc., has not been more than referred to in the discussion.

MAINTENANCE.

Someone has said that the maintenance of a macadam road should begin on the day the road is completed. In a sense this statement is not far from the truth. It is usually not necessary to do much to the macadam surface for a year or two; but the gutters, catch basins, and culverts must be kept clean, the weeds along the roadsides must be cut or, preferably, pulled out by the roots, and the small gullies in the shoulders and on the slopes filled before they become too large.

It is quite possible, particularly if the road was built in the fall of the year and trap rock was used, that loose stones will appear on the surface the first spring after the road is opened to travel. These need not alarm the road official. They should be picked up and stacked for future use. It is astonishing how a few loose stones on the surface of a macadam road will have the appearance of a great number, so that the uninformed always think, and frequently say, that the road is going to pieces. It is a fact that often such stones will disappear into the macadam after the first rain.

Of course the macadam will become worn in time and need repair. No one can state accurately how much of the macadam surface will wear off in a given time. The dictum, heard so often, that the macadam will wear down one-half inch in a year's use is a fallacy. The length of life of a properly built macadam road depends especially upon the volume and kind of traffic over it, the quality of the stone of which it is composed, and its peculiar fitness to resist the wear to which it is subjected; also upon the climatic conditions of the locality.

A certain Massachusetts road, built in the best manner of an excellent quality of trap rock, needed resurfacing within two years after it was completed. The road was a portion of a main thoroughfare just outside of one of the largest cities in the State. In addition to the usual heavy traffic to which such a road must be subjected, it was used constantly by drays loaded with the products of several mills. On the other hand, there are many miles of State roads in Massachusetts built of broken field stones and in use for ten or twelve years on which little or no surface repairs have been needed. In the first case mentioned it was probably a mistake to have used the macadam type of surfacing. Vitrified paving brick, or possibly blocks of granite or some other hard material, would have better suited the conditions. In the latter case the field stones have served their purpose admirably, though some of the roads could and probably would have been built of gravel had that material been obtainable at a reasonable cost.

It was formerly held that the macadam surface should be restored annually to its original thickness. Doubtless this practice was excellent, so far as the condition of the roads was concerned, but such annual restoration is costly. The present practice is to keep the surface always smooth, to fill any small holes or incipient ruts which may appear, but to do no resurfacing until the stones have worn down at least to the lower stratum of the macadam. Too often the resurfacing is delayed longer than economical considerations will justify.

By the time the upper course has been worn through, the road is usually more or less out of shape. As before stated, most of the wear is near the middle of the road. The sides tend to build up as the center wears down. When the road is in this condition it should be resurfaced with the best stone which is available. It should not be necessary to put on more than 3 inches in the center and the stone at the sides may be spread as thinly as is possible. Usually the road surface is " spiked up " with the picks in the wheels of the steam roller. There are several so-called " scarifiers " on the market, which are sometimes used, but they are seldom needed on country roads. Sometimes no " spiking " is needed if 3 inches or more of stone is put on, since this depth will usually give a sufficient body to hold together.

Such resurfacings are usually relatively inexpensive. There is no trouble with the foundation and the stones settle quickly into place and stay there. When the resurfacing is completed the road is as good as new. It has been stated that such work should be done in Massachusetts at not exceeding 10 cents per square yard for each inch in depth of new surfacing material rolled in place. This is a liberal estimate for most work of this kind.

In Massachusetts, where the highway commission not only directs the original construction of the roads but their maintenance as well, it is necessary to keep account of the repair costs accurately, since the counties and municipalities, respectively, are assessed annually for certain percentages of the expenses. The State roads there, at least 95 per cent of which are of the macadam type, have averaged for ordinary maintenance, approximately $100 per mile per year. These roads, almost all of which are 15 feet wide in the macadamized portion, have been in service for one to thirteen years. A few sections now require resurfacing and each year some of this work is done. Only a relatively small part of the resurfacing cost is included in the annual cost per mile above stated, but it is believed that an expenditure of not exceeding $200 per mile per year should be the maximum amount necessary to provide for both ordinary and extraordinary repairs.

At the present time the worst foe of the macadam road is, perhaps, the motor vehicle. The steel wheels of the ordinary vehicle grind off sufficient powder from the stones to serve as a binder, replacing the binding material blown away by winds or washed off by rains. It is usually possible, when the binder becomes deficient and the stones in the upper course begin to appear, to spread a little coarse sand in the center of the macadam road. The sand is soon spread by traffic over the greater portion of the width of the macadam. It relieves the roughness and keeps the stone from raveling. This practice has been followed in many sections for years. But the swiftly moving motor car of the present day has introduced a new problem into road maintenance. The large rubber tires on wheels of small diameter appear to exert a suction on the binder of the road. The vehicle moving rapidly over the road lifts the dust into the air in clouds, and it is blown away into the fields.

Various substances are now being applied to road surfaces to lessen or obviate this evil. Coal tar and oils with an asphaltic base seem to give the best results. In France tar has been used for several years, it is said, most satisfactorily. It may be that by some such application not only will the roads be saved from denudation by motor vehicles, but the costs of ordinary surface repairs will be lessened as well.

A properly built macadam road in the country rarely becomes muddy except from mud tracked upon it from side roads built of earth. That they are often dusty can not be denied. Watering or sprinkling is a luxury that can not often be afforded on country roads. When properly applied, water not only lessens the dust nuisance, but preserves the road as well.

No one with experience in such matters will contend that a macadam road may generally be maintained at a less cost than a gravel or an earth road. Sometimes under certain conditions its cost of maintenance may be less, but not usually. But it is true that a macadam road, such as is recommended in this bulletin, may at a moderate expense be kept smooth, hard, and serviceable at all times of the year and that these requirements can not be met by either the earth or the gravel road.

A series of drawings of standard details of Massachusetts roads (figs. 3-10) will be found on pages 36 to 39.

APPENDIX.

MASSACHUSETTS SPECIFICATIONS.

The following are excerpts from specifications used in the construction of State-aid roads in Massachusetts:

Earthwork.

The roadbed shall be graded for the width of ——— true to the lines and grades given by the engineer and in conformity with the plans, profiles, and cross sections furnished by the commissioners, and so shaped that after the broken stone is rolled in place the surface of the roadway shall have a crown of three-quarters of an inch to the foot.

All clay and spongy material shall be removed to a depth to be determined by the engineer, and the space thus made shall be filled with such material as the engineer may direct.

In general, embankments will be made from material from within the location of the road, as will also all filling and grading, but if there is not sufficient suitable material in the excavation, in the opinion of the engineer, the contractor shall find such material outside of the highway location. Such material will be classed as borrow.

Embankments shall be formed of successive layers of not more than twelve (12) inches in thickness, each layer to be thoroughly rolled by a roller weighing not less than two tons.

All trees, stumps, and roots within the roadbed and on slopes shall be grubbed up and removed as the engineer may direct, without additional compensation.

Ditches of such width and depth as the engineer may direct shall be excavated by the contractor wherever the engineer may order them, at the contract price for excavation.

All surfaces in slopes or on embankments, whether old or new, shall be left with neat and even surfaces according to the lines, grades, and directions given by the engineer, without additional compensation.

All measurements of earthwork shall be made in excavation.

Material obtained from excavation within the limits of the location and used in embankments, or for any other purpose, will be paid for as excavation only.

Allowance for culvert excavation will include only one (1) foot outside of the masonry sections, as shown on plans.

Borrow.

When, in the opinion of the engineer, there is not sufficient suitable material within the limits of the highway location of the section under contract to form the necessary embankments, or for subgrading, or for shoulders, the contractor shall obtain such material from outside the highway location. This material shall be known as borrow, and may be of any quality satisfactory to the engineer for the purpose for which it is required.

If found within a radius of one thousand (1,000) feet from any point on said section under contract it will be paid for at the borrow price.

If, however, in the opinion of the engineer, no suitable material can be obtained within the limit just described, the contractor shall find satisfactory material at a greater distance. In this event, in addition to the regular borrow price, the sum of one-half (½) cent per cubic yard for each one hundred (100) feet of overhaul shall be allowed him for all material so supplied, the length of haul to be measured from the pit along the shortest available route to the one thousand (1,000) foot limit above described.

Borrow pits will be cross-sectioned and all quantities will be measured in the pits.

Ledge Excavation.

Only such ledge as requires blasting for its removal, and boulders of one-half (½) a cubic yard or more in volume, will be estimated as ledge excavation.

No allowance for ledge excavation in the roadbed shall be made outside of or for more than twelve (12) inches below the lines indicated on the cross sections showing the finished surface, the side slopes to be one-fourth (¼) to one (1).

Allowance for ledge in drains will be made on the basis of a width of trench of two (2) feet and a depth of four (4) inches below the invert of the pipe; allowance for ledge in gutters will be made on the basis of the width of the gutter and twelve (12) inches in depth below the proposed surface.

Culverts.

Reinforced Portland cement concrete culverts shall be constructed where ordered by the engineer to the lines and grades given by him.

Culvert ends shall be laid parallel to the center line of the roadway. All culvert masonry shall be measured in accordance with the dimensions shown on the plans.

No allowance shall be made for cofferdams, pumps, labor, etc., which may be necessary on account of water.

Portland Cement Concrete Masonry.

The concrete shall be composed of broken stone or screened gravel, and sand—all of which shall be clean, hard, durable, sharp, and free from clay, dirt, and other objectionable material—Portland cement and fresh, clean water.

To each part of Portland cement there shall be by volume two (2) parts of sand and five (5) parts of broken stone or screened gravel, and such a proportion of water as the engineer may from time to time determine.

The broken stones or gravel stones shall be of the following sizes:

For all work less than six (6) inches in thickness the stones may vary in their longest dimension from one-quarter (¼) of an inch to three-quarters (¾) of an inch; between six (6) inches and twelve (12) inches, from one-quarter (¼) of an inch to one and one-quarter (1¼) inches; more than twelve (12) inches in thickness, from one-quarter (¼) inch to two and one-half (2½) inches.

The cement and sand shall first be thoroughly mixed dry, in the proportions specified, in proper boxes. Clean water shall then be added and the materials thoroughly mixed. The broken stone, previously drenched with water, shall then be deposited in this mixture and the ingredients thoroughly mingled and turned over until each stone is covered with mortar. The batch shall then be carefully deposited without delay and thoroughly rammed in layers not more than six (6) inches in depth until the water flushes to the surface and all the voids are filled.

The concrete shall not be allowed to fall from any considerable height.

Before the concrete is placed in the moulds, a sheet-iron plate, six or eight inches in width and about six feet long, or of such other dimensions as the contractor may find convenient, shall be held in position one and one-half (1½) inches from the surface of the mould or form. The space between the form and this separator shall be filled with mortar, composed of one part of Portland cement and one part of sand, mixed to such a consistency as the engineer may direct, and, if he shall so direct, the mortar shall be thoroughly spaded after it is placed. Only a small batch shall be mixed at a time, and then only as needed. Immediately after the space between the separator and the form is filled with mortar the ordinary concrete shall be placed behind the separator, the separator removed, and the backing and facing thoroughly rammed together to a close bond. No delay shall be permitted in placing the concrete backing, and both the facing and the backing shall be done as nearly simultaneously as is possible.

Should voids be discovered when the forms are taken down, the defective work is to be removed and the space refilled with one to one cement mortar. The exposed surfaces shall be smoothed over with a neat Portland cement grout, laid on with a brush, until a smooth surface is secured.

Centres and forms, satisfactory to the engineer, shall be provided by the contractor. They shall be made of planed lumber and shall fit the curves and shapes of the work. The sheathing shall be laid tight and shall be made clean before using.

The centres shall be true to the lines, satisfactorily supported and firmly secured, and shall remain in place as long as the engineer may direct, and shall be replaced by new ones when they lose their proper dimensions or shape.

In connecting concrete already set with new concrete, the surface shall be cleaned and roughened and mopped with a mortar composed of one part Portland cement and one part sand.

When work is done under such conditions that the mortar is liable to freeze, the contractor shall provide the necessary means for and shall thoroughly heat all materials, and also the water, and shall thoroughly protect the masonry from damage by rain and frost during and after laying.

During warm and dry weather, and whenever the engineer may direct, all newly built concrete shall be kept well shaded from the sun and well sprinkled with water until set.

In laying concrete under water the concrete shall not fall from any considerable height, but be deposited in the allotted place in a compact mass. The concrete must not be rammed, but leveled with a rake or other suitable tool immediately after being deposited. No concrete shall be laid in running water.

Expanded metal or twisted rods, to be furnished to the contractor by the commission, shall be imbedded in the concrete by the contractor as directed by the engineer, without extra compensation.

No back-filling or loading whatever shall be placed on or against the concrete masonry until ordered by the engineer.

The Massachusetts highway commission will furnish all cement to be used in this work and will deliver it to the contractor at the nearest railroad freight station. The contractor shall, at his own expense, team the cement to the work and store it, and protect it from the weather to the satisfaction of the engineer.

The price to be paid per cubic yard for concrete masonry shall include the back-filling and all necessary centres and forms, and all work on the same, and no allowance shall be made for cofferdams, pumping or bailing, or for any materials or labor necessary on account of water.

All concrete shall be measured in accordance with the dimensions shown on plans.

Shaping Surface for Broken Stone.

Before the broken stone is spread the roadbed shall be shaped to a true surface, conforming to the proposed cross section of the highway and rolled by a steam roller, unless otherwise ordered by the engineer. All depressions occurring must be filled with suitable material and again rolled, until the surface is smooth and hard, the width to be paid for to include only the width of broken stone.

Broken Stone.

Broken stone, consisting of ———, shall be spread and rolled on the roadbed prepared as hereinbefore described, as follows:

The width of the broken stones shall be ——— (—) feet.

All broken stone used shall be laid in layers or courses. The bottom course shall consist of stones from one and one-quarter (1¼) inches to two and one-half (2½) inches in their longest dimension; the upper course of stone from one-half (½) inch to one and one-quarter (1¼) inches in their longest dimension.

The bottom course shall be ——— (—) inches deep at the centre and ——— (—) inches deep at the sides after rolling. The top course shall be ——— (—) inches deep at the centre and ——— (—) inches deep at the sides after rolling.

After the two courses above described are thoroughly compacted, broken-stone screening shall be laid on, watered, and rolled until the mud flushes to the surface. The screenings so used shall not be larger than will pass through a half-inch mesh and shall contain all the dust. Care must be taken to lay on only enough of the screenings to cover the larger stones.

Each course, bottom, top, and binder, shall be rolled separately by a steam roller and evened up with material of the same size and quality as has been used in that particular course, and to the satisfaction of the engineer.

All broken stone shall be spread from the carts by hand, or from a dumping board, or from self-spreading carts.

No soft or disintegrated stone shall be used.

If so ordered by the engineer the thickness of the broken stone shall be increased or diminished at such points as he may direct.

The grade of the finished surface of the road shall present a crown of three-quarters (¾) of an inch to the foot.

If local stone or stone not shipped by rail is used it shall be weighed on scales furnished by and at the expense of the contractor. Said scales shall be satisfactory to the engineer and they shall be sealed at the expense of the contractor as often as the engineer may deem necessary to insure their accuracy.

A sworn weigher, to be appointed and compensated by the Massachusetts highway commission, shall weigh all broken stone required to be weighed as above provided.

If the stone is shipped by rail the car weights will be accepted.

Vitrified Clay Pipe and Iron Water Pipe (for Culverts).

Vitrified clay pipe and iron water pipe shall be furnished and laid where directed by the engineer.

All clay pipe shall be of first quality, salt glazed, free from blisters and cracks, straight and round. If eighteen (18) inches or more in diameter, the pipe shall be "double strength," or if ordered by the engineer, ordinary pipe may be used and laid in concrete, which shall be tamped about the pipe to the satisfaction of the engineer. If, however, concrete is used, it shall be paid for at the regular price for concrete.

All iron pipe shall be of the best quality of water pipe and free from imperfections of any kind.

All pipe shall be laid true to the lines and grades furnished by the engineer. Nothing but selected fine material, free from large stones, shall be placed around and under the pipe, and all material placed under and about the pipe shall be thoroughly tamped in place by a thin iron tamping bar. All joints shall be made of first quality natural cement mortar, mixed in proportion of one (1) part cement to one (1) part of clean, sharp sand, carefully filled in all around the pipe. The ends of pipe drains used as culverts must be protected by concrete masonry or concrete walls. The price per foot paid for pipe laid as above includes the cost of trenching and back-filling, and all incidental work except the masonry ends; *provided, however*, that when the depth of the trench exceeds five (5) feet all excavation necessary on account of additional depth shall be paid for by the cubic yard at the regular contract price for excavation.

Guard Rail.

Fencing shall be placed on edges of embankments and at such other places along the road as the engineer may deem necessary. It shall be of the section shown on plan; the posts shall be of well-seasoned, straight, sound chestnut or cedar, not less than six (6) inches in diameter, spaced eight (8) feet apart on centres, the bottom of each post to be sawed off square and set plumb in straight lines, three (3) feet into the ground and three and one-half (3½) feet above the ground, and the back-filling thoroughly tamped. All bark shall be removed before setting, all knots hewn down to face and the exposed surfaces shaved. The top rails shall be four (4) inches square and the side rails of two by six (2 × 6) inch well-seasoned, straight-grained spruce or other wood satisfactory to the engineer, planed, free from loose or unsound knots, and both top and side rail shall be notched into and securely fastened to the posts, as shown in the plan, and be long enough to extend over three (3) posts and break joints.

All parts of the exposed surface of the fence shall be painted with one coat of white lead and linseed oil.

At culverts, square iron posts, one and one-quarter (1¼) inches square, shall be used, set into the coping stone at least four (4) inches, and leaded. The side rail shall be bolted to the iron posts with two bolts set in holes drilled through each post.

Side Drains.

Drains will be built where directed by the engineer.

All drains must be carried to an outlet approved by the engineer.

The drain trench shall be excavated to a width of twelve (12) inches at the bottom and fifteen (15) inches at the top, and shall be excavated only as fast as the drain can be finished.

When the grade of the finished road is three (3) inches or more to the hundred (100) feet, the bottom of the drain trench must be three and one-half (3½) feet below the finished surface of the road at that part of the cross section.

On the bottom of this trench shall be placed two (2) inches of gravel or broken stone which will pass through a one and one-quarter (1¼) inch mesh, and not through a half (½) inch mesh.

On this material shall be laid a five (5) inch salt-glazed vitrified clay pipe, with bell and spigot joints, unless otherwise ordered, with open joints, and the bell ends toward the rising grade.

All pipe must be laid true to a line and grade, and no pipe is to be laid on a grade of less than three (3) inches in one hundred (100) feet.

Gravel or broken stone of the sizes already described shall be filled about the pipe and over it for a depth of one (1) foot. This must be carefully tamped about and rammed over the pipe. The remainder of the trench is to be filled with stone which will pass through a three (3) inch and not through a one (1) inch mesh, and this material shall be thoroughly tamped. Any sand, silt, or earth getting into the pipe or the interstices of the stone in the trench must be removed by the contractor at his own cost, even if it be necessary to rebuild the drain.

Where, in the opinion of the engineer, it is necessary to extend a drain to an outlet beyond the section needing to be drained, the pipe will be laid with cement joints, true to line and grade, and the gravel or stone in the trench omitted, the trench being back-filled with the material excavated from the same.

Where a pipe is carried through a bank the outlet must be protected by masonry, as provided in pipe culverts.

The price per lineal foot includes the cost of trenching and refilling with gravel or broken stone, the cost of the pipe and laying, as well as all incidental work.

No allowance will be made for pipe larger than above specified laid in any drain unless the larger pipe has been ordered in writing by the engineer.

Stone Filling.

At such places as the engineer may direct, stone filling shall be placed. Excavations shall be made to the lines shown on the cross sections. The stones may be either wall stones or cobbles ranging in size from the smallest obtainable to those not exceeding eight (8) inches in their longest dimension, and the larger stones shall be placed at the bottom.

The excavation will be paid for at the regular price for excavation.

The stone filling will be measured according to the original cross sections, without allowance for shrinkage or settlement, and paid for by the cubic yard.

Catch Basins.

Catch basins will be built of brick masonry or Portland cement concrete, as shown on plan and in accordance with the directions of the engineer.

All bricks used shall be well formed and hard burnt and shall be well soaked in water before laying.

The joints shall be thoroughly flushed full of mortar, consisting of one part of natural cement of the best quality and two parts of coarse, clean, sharp sand, free from loam and pebbles.

No joint on the face shall be greater than one-quarter inch.

After the bricks are laid the joints shall be neatly pointed on the inside.

As the walls are laid up they shall be well plastered with mortar on the outside.

The contractor is to furnish all labor, tools, and materials necessary for the basins, excepting the frames and grates, which will be furnished by the commission, and delivered at the railroad freight station nearest to the site of the work. The price paid for each basin will include all excavation, back filling, and incidental work.

Cobble-Stone Gutters.

Paved gutters will be built where directed by the engineer, the same to be laid by journeymen pavers.

No gutter is to be laid until after the broken stone has been rolled, unless [illegible]wise ordered by the engineer.

In no case is the roller to pass over any part of any paved gutter.

Gutters not exceeding four hundred (400) feet in length shall be three (3) feet wide with a shoulder one (1) foot wide and a dish of three (3) inches.

Gutters exceeding four hundred (400) feet in length shall increase the dish above this length at the rate of one (1) inch to each three hundred (300) feet.

All stone used in gutters shall be rounded field, bank, or river stone; no flat, shaky, or rotten stone shall be used.

The stone may, on the average, lay from four (4) to six (6) square yards to the ton. A cubic yard may be estimated to weigh one and one-third (1⅓) tons.

The larger selected stone will be laid in the gutter row and on the edges to a true line and grade, with the largest diameters lengthwise of the road. All other stone will be laid with the longest diameters across the gutter.

The trench shall be excavated to a depth of twelve (12) inches below the finished grade of the gutter; gravel shall then be spread and rammed to a depth of four (4) inches. A layer of bedding sand, or gravel free from stone larger than one-half (½) inch in diameter, shall then be spread to a sufficient thickness to bring the gutter stone which are bedded in it to the proper grade and cross section after they are thoroughly rammed.

Each stone is to be rammed to an unyielding foundation. The contractor shall employ one rammer to every two pavers. The surface shall then be covered with coarse sand or fine-screened gravel free from clay or dirt, which must be well broomed into all joints. The stone shall then be rerammed and the surface left smooth and even. If from any cause the stone in a gutter shall have been disturbed and left uneven, they must be relaid by the contractor and at his cost. Sand or screened gravel shall then be spread over the entire surface of sufficient depth to fill all interstices.

The edge of the gutter toward the road shall be left one-quarter (¼) inch below the surface of the adjoining broken stone; in no case must it project above it.

All broken stone which may be disturbed during the paving of the gutter must be carefully replaced and thoroughly rammed.

The bank on the outside of the gutter must be sloped to the gutter, so as to have no bunches or depressions on its surface.

COST OF MACADAMIZED ROADS IN MASSACHUSETTS.

Tables 7 to 11 show the actual costs to the Commonwealth of Massachusetts of broken stone in place on State highways completed during the year 1906; also average contract prices for other items of construction.

TABLE 7.—*Imported stone (trap rock).*[a]

City.	Length in feet.[b]	Square yards.	Number of tons.	Square yards per ton.	Cost per ton in place.	Cost per square yard in place.	Total cost of stone in place.	Cost per mile.[b]
gawam	3,400	5,667	1,702.67	3.33	$2.10	$0.6309	$3,575.61	$5,552.00
edford	2,798	4,663	1,523.40	3.06	2.15	.7024	3,275.31	6,180.00
hicopee	2,100	3,500	1,175.00	2.98	2.30	.7721	2,702.50	6,788.00
oncord	3,334	5,557	1,627.50	3.41	1.85	.5418	3,010.87	4,768.00
eerfield	2,222	3,703	1,202.20	3.08	1.70	.5519	2,043.74	4,856.00
ast Longmeadow	2,409	4,015	1,295.50	3.00	1.80	.5808	2,331.90	5,111.00
ranby	2,677	4,461	1,516.00	2.94	2.25	.7646	3,411.00	6,728.00
reenfield	2,350	3,917	1,130.90	3.46	1.75	.5053	1,979.08	4,447.00
roveland	1,493	2,488	839.80	2.96	1.925	.6480	1,616.61	5,702.00
atfield	1,750	2,917	968.50	3.01	1.75	.5810	1,694.87	5,113.00
orth Brookfield	2,750	4,583	1,475.85	3.10	2.00	.6441	2,951.70	5,668.00
ttsfield	2,560	4,267	1,276.25	3.26	1.90	.5683	2,424.87	5,001.00
nderland	1,200	2,000	695.26	2.88	2.00	.6953	1,390.52	6,119.00
wksbury	3,924	6,540	2,328.00	2.81	2.20	.7831	5,121.60	6,891.00
est Springfield	4,000	6,667	1,884.55	3.54	1.70	.4805	3,203.74	4,228.00
hately, 1905	3,423	5,704	1,854.52	3.07	1.75	.5689	3,245.41	5,006.00
hately, 1906	1,178	1,964	684.75	2.87	2.00	.6971	1,369.50	6,134.00
Totals and averages	[c]43,568	[c]72,613	[c]23,180.65	[d]3.13	[d]1.956	[d].6245	[c]45,348.83	[d]5,496.00

[a] Six inches in depth at center; 4 inches in depth at sides.

[b] Equated to basis of road 15 feet wide.

[c] Total.

[d] Average.

TABLE 8.—*Imported stone (trap rock).*[a]

City.	Length in feet.[b]	Square yards.	Number of tons.	Square yards per ton.	Cost per ton in place.	Cost per square yard in place.	Total cost of stone in place.	Cost per mile.[b]
Chatham	5,217	8,695	2,206.67	3.94	$1.95	$0.4953	$4,306.52	$4,350.00
Concord	5,114	8,523	2,491.40	3.42	1.798	.5241	4,466.83	4,611.00
Dennis	4,353	7,255	1,956.03	3.71	2.20	.5930	4,303.27	5,218.00
Falmouth	1,855	3,092	801.60	3.86	2.75	.7127	2,204.40	6,272.00
Grafton	2,640	4,400	1,173.35	3.74	2.00	.5333	2,346.70	4,693.00
Huntington	2,421	4,035	1,071.00	3.77	1.90	.5043	2,034.90	4,438.00
Kingston	5,366	8,943	2,367.60	3.78	2.05	.5427	4,853.58	4,776.00
Templeton	3,100	5,167	1,437.70	3.59	1.93	.5370	2,774.76	4,726.00
Wareham	6,752	11,254	2,832.40	3.97	2.05	.5159	5,806.42	4,540.00
Totals and averages	[c]36,819	[c]61,365	[c]16,330.55	[d]3.76	[d]2.025	[d].5398	[c]33,097.38	[d]4,746.00

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[a] Four inches in depth throughout.
[b] Equated to basis of road 15 feet wide.
[c] Total.
[d] Average.

TABLE 9.—*Local stone.*[a]

City.	Length in feet.[b]	Square yards.	Number of tons.	Square yards per ton.	Cost per ton in place.	Cost per square yard in place.	Total cost of stone in place.	Cost per mile.[b]
Auburn	7,686	12,810	4,119.00	3.11	$1.41	$0.4534	$5,807.79	$3,990.00
Bellingham	1,208	2,013	650.00	3.10	1.65	.5327	1,072.50	4,688.00
Bellingham, 1905	3,856	6,425	2,020.00	3.18	1.30	.4087	2,626.00	3,597.00
Bellingham, 1906	4,870	8,117	2,511.44	3.23	1.30	.4022	3,264.87	3,539.00
Berkley	4,045	6,742	1,993.37	3.38	1.35	.3991	2,691.05	3,512.00
Beverly	4,861	8,102	2,206.45	3.67	1.55	.4221	3,420.00	3,714.00
Bridgewater	3,300	5,500	1,455.50	3.78	1.35	.3572	1,964.92	3,143.00
Burlington	5,160	8,600	2,522.45	3.41	1.45	.4253	3,657.55	3,743.00
Charlton	2,792	4,653	1,538.50	2.99	1.45	.4794	2,230.82	4,219.00
Douglas	2,822	4,704	1,408.00	3.34	1.48	.4429	2,083.84	3,898.00
Dracut	6,500	10,833	3,454.80	3.14	1.44	.4592	4,974.91	4,041.00
Dighton	2,915	4,858	1,781.66	2.73	1.50	.5501	2,672.50	4,841.00
Framingham	6,737	11,228	2,714.67	4.14	1.157	.2800	3,142.17	2,464.00
Gloucester	2,883	4,805	1,440.00	3.34	1.70	.5094	2,448.00	4,483.00
Hudson	4,039	6,732	2,046.49	3.29	1.44	.4377	2,946.95	3,852.00
Melrose-Saugus	3,100	5,167	1,543.28	3.35	1.25	.3733	1,929.10	3,285.00
Middleboro	3,807	6,345	1,892.88	3.35	1.25	.3729	2,366.10	3,281.00
Millbury	3,100	5,167	1,692.68	3.05	1.40	.4586	2,369.75	4,036.00
Montague	3,958	6,597	2,032.80	3.24	1.55	.4776	3,150.84	4,203.00
Norton	2,650	4,416	1,300.00	3.39	1.65	.5006	2,145.00	4,405.00
Oxford	4,482	7,470	2,349.00	3.18	1.374	.4325	3,229.74	3,806.00
Rehoboth	3,473	5,788	1,580.00	3.66	1.25	.3412	1,975.00	3,002.00
Southboro	5,985	9,975	3,437.00	2.90	1.30	.4479	4,468.10	3,942.00
Stoughton	7,006	11,677	3,445.02	3.39	1.40	.4130	4,823.03	3,634.00
Swansea	7,612	12,687	3,087.30	4.11	1.25	.3042	3,859.12	2,677.00
W. Newbury, 1905	3,936	6,558	2,178.29	3.01	1.49	.4949	3,245.65	4,355.00
W. Newbury, 1906	2,000	3,333	1,158.33	2.88	1.55	.5387	1,795.41	4,741.00
Totals and averages	[c]114,782	[c]191,307	[c]57,558.91	[d]3.32	[d]1.396	[d].4201	[c]80,360.71	[d]3,696.00

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[a] Six inches in depth at center; 4 inches in depth at sides.
[b] Equated to basis of road 15 feet wide.
[c] Total.
[d] Average.

TABLE 10.—*Local stone.*[a]

City.	Length in feet.[b]	Square yards.	Number of tons.	Square yards per ton.	Cost per ton in place.	Cost per square yard in place.	Total cost of stone in place.	Cost per mile.[b]
ton, 1905	3,000	5,000	1,221.30	4.09	$1.54	$0.3762	$1,880.80	$3,310.00
ton, 1906	4,450	7,417	1,955.84	3.79	1.55	.4087	3,031.55	3,596.00
lmark	7,042	11,736	2,980.90	3.80	1.80	.4572	5,365.62	4,023.00
acester	1,733	2,889	728.00	3.97	1.70	.4284	1,237.60	3,770.00
caster-Sterling	5,245	8,743	2,173.28	4.01	1.50	.3728	3,259.92	3,280.00
dham	5,490	9,150	2,366.79	3.86	1.40	.3621	3,313.51	3,186.00
kland	2,329	3,882	1,065.73	3.64	1.75	.4804	1,865.03	4,228.00
eham	5,362	8,937	1,845.33	4.84	1.49	.3079	2,749.54	2,709.00
otals and averages.	[c]34,651	[c]57,754	[c]14,337.17	[d]4.03	[d]1.583	[d].3931	[c]22,703.57	[d]3,459.00

[a] Four inches in depth throughout.
[b] Equated to basis of road 15 feet wide.
[c] Total.
[d] Average.

BLE 11.—*Averages of contract prices for the several construction items, exclusive of macadam.*

cavation	per cubic yard	$0.4352
rrow	do	.5622
lge excavation	do	1.78
nent concrete masonry	do	[a]8.85
aping road for broken stone	per square yard	.0281
rified 12-inch clay pipe, in place	per linear foot	.7662
rified 10-inch clay pipe, in place	per linear foot	$0.6430
rified 8-inch clay pipe, in place	do	.57
rified 18-inch clay pipe, in place	do	1.57
inch iron water pipe, in place	do	2.20
inch iron water pipe, in place	do	3.75
ne filling for V-drains, in place	per cubic yard	.8271
ard rail, in place	per linear foot	.2770
tch-basins, in place (including catch-basin frames and grates)	each	35.74
ting stone bounds	do	1.85

COST OF STATE-AID ROADS IN NEW JERSEY.

Tables 12 to 14 give the costs of State-aid roads in New Jersey 1905, as shown in the Report of the Commissioner of Public ads of that State for 1905 (pp. 85–87):

TABLE 12.—*Stone bed 4 inches deep.*

Width of stone.	Length.	Length of road if 15 feet wide.	Area.	Unit price per square yard.	Total cost.	Cost per mile of road 15 feet wide.
Feet.	*Feet.*	*Feet.*	*Sq. yards.*			
28	2,287	4,202	7,136	$0.3500	$2,497.74	$3,080.00
28	5,078	9,479	15,610	.3300	5,151.30	2,904.00
16	5,572	5,943	10,398	.1800	1,871.64	1,584.00
14	15,415	14,387	23,979	.1800	4,316.22	1,584.00
	[b]28,352	[b]34,011	[b]57,123	[c].2422	[b]13,836.90	[c]2,148.00

This price does not include the cement or the steel reinforcement, which may be esti-ed at about $3 additional.
Total.
Average.

TABLE 13.—*Stone bed 6 inches deep.*

Width of stone.	Length.	Length of road if 15 feet wide.	Area.	Unit price per square yard.	Total cost.	Cost per mile of road 15 feet wide.
Feet.	*Feet.*	*Feet.*	*Sq. yards.*			
14	12,195	11,382	19,222	$0.6000	$11,533.20	$5,280.00
14	5,361	5,004	9,105	.6100	5,554.05	5,368.00
16	8,335	3,557	5,986	.7000	4,190.20	6,160.00
14	8,050	7,513	12,522	.6700	8,389.74	5,896.00
14	10,910	10,183	16,971	.6200	10,522.02	5,456.00
	a 39,851	a 37,639	a 63,806	b .6299	a 40,189.21	b 5,637.00

a Total. b Average.

TABLE 14.—*Stone bed 8 inches deep.*

Width of stone.	Length.	Length of road if 15 feet wide.	Area.	Unit price per square yard.	Total cost.	Cost per mile of road 15 feet wide.
Feet.	*Feet.*	*Feet.*	*Sq. yards.*			
12	7,385	5,908	9,847	$1.0000	$9,847.00	$8,800.00
14	5,393	4,981	8,244	.6128	5,052.26	5,393.00
14	14,665	13,687	23,193	.7200	16,698.96	6,336.00
16	20,949	22,346	38,208	.60	23,057.00	5,280.00
14	9,940	9,277	15,623	.70	11,076.50	6,160.00
14	16,608	15,501	26,237	.74	19,519.08	6,512.00
12	5,280	4,224	7,040	.5749	4.047.20	5,059.00
12	7,410	5,928	9,880	.6593	6,513.40	5,802.00
12	7,448	5,958	9,930	.67	6,652.83	5,896.00
14	7,720	7,205	12,090	.75	9,067.20	6,600.00
14	16,400	15,307	25,511	.73	18,623.03	6,424.00
12	5,700	4,560	7,600	.58	4,408.00	5,104.00
	a 124,898	a 114,882	a 193,403	b .6958	a 134,562.46	b 6,187.00

a Total. b Average.

SKETCHES OF STANDARD DETAILS.

[Massachusetts State roads.]

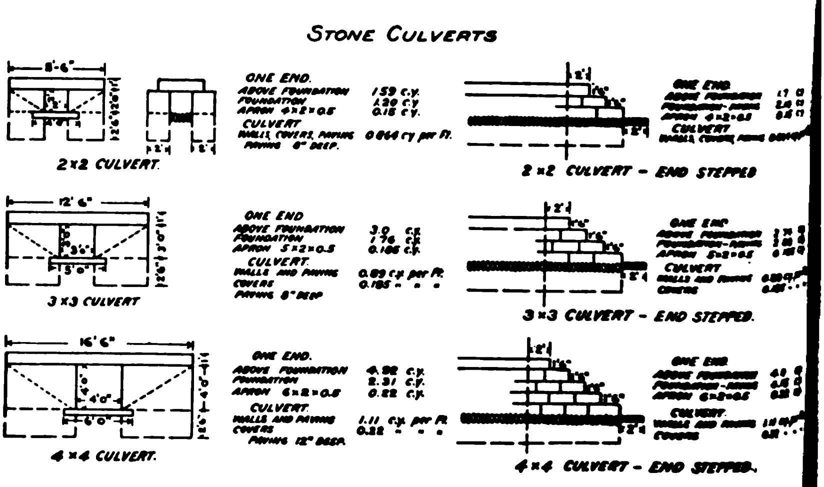


FIG. 3.

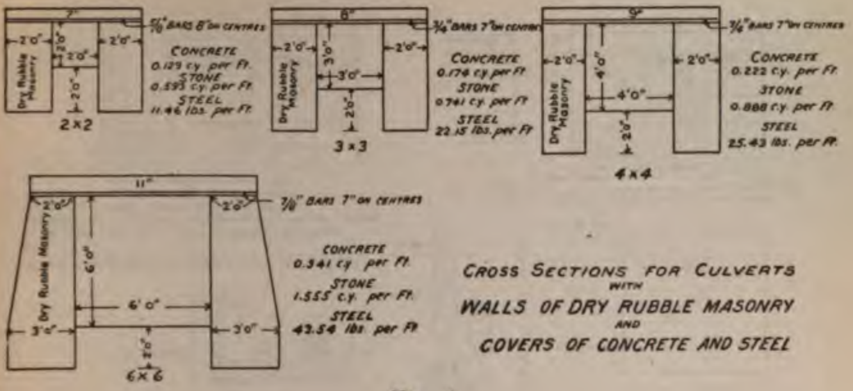


FIG. 4.

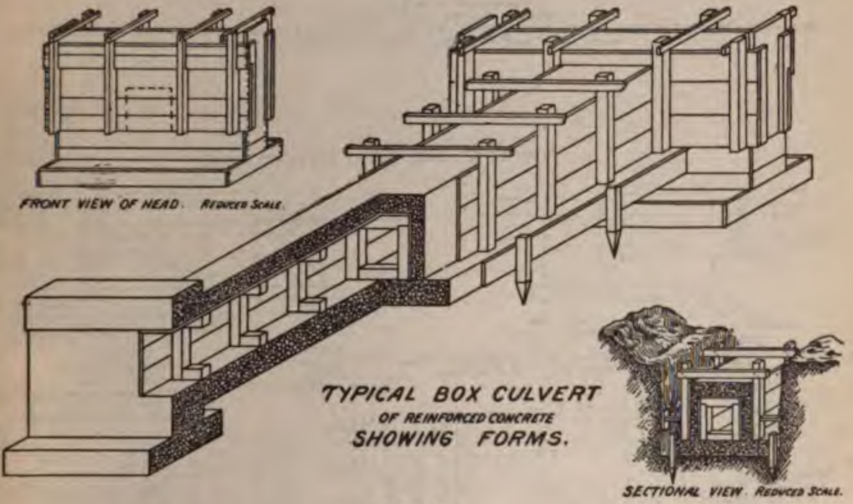

FRONT VIEW OF HEAD. REDUCED SCALE.
TYPICAL BOX CULVERT
OF REINFORCED CONCRETE
SHOWING FORMS.
SECTIONAL VIEW. REDUCED SCALE.

FIG. 5.

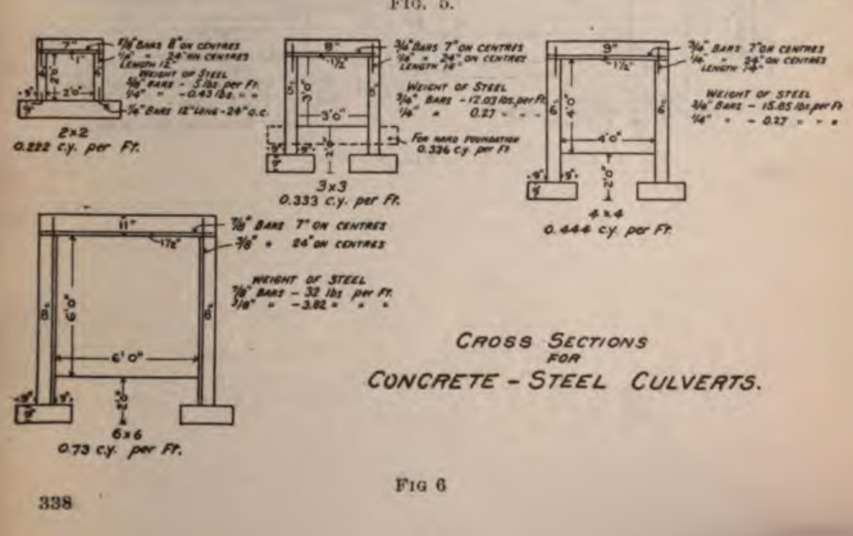


FIG 6

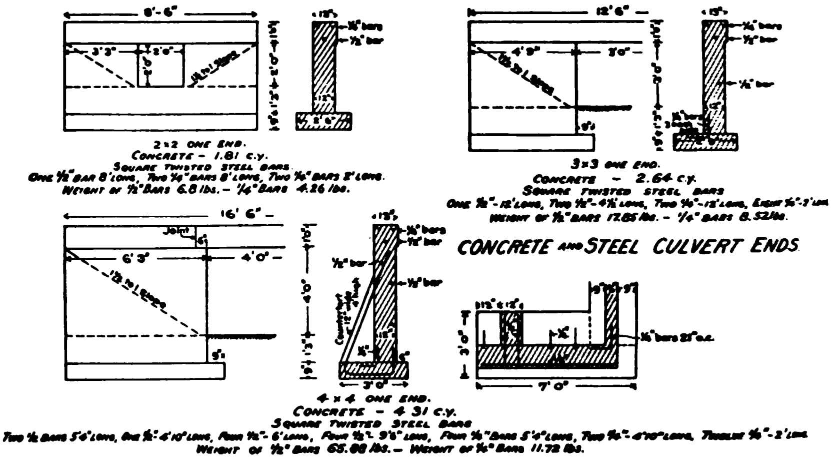

8'-6"
3'3"
2'0"
1½ to 1 Slope
2×2 ONE END.
CONCRETE - 1.81 C.Y.
SQUARE TWISTED STEEL BARS.
ONE ½" BAR 8' LONG, TWO ¼" BARS 8' LONG, TWO ¼" BARS 2' LONG.
WEIGHT OF ½" BARS 6.8 lbs. - ¼" BARS 4.26 lbs.
12'6"
4'9"
3'0"
1½ to 1 Slope
3×3 ONE END.
CONCRETE - 2.64 C.Y.
SQUARE TWISTED STEEL BARS
ONE ½"-12' LONG, TWO ½"-4½' LONG, TWO ¼"-12' LONG, EIGHT ¼"-2' LONG
WEIGHT OF ½" BARS 17.85 lbs. - ¼" BARS 8.52 lbs.
CONCRETE AND STEEL CULVERT ENDS
16'6"
Joint
6'3"
4'0"
1½ to 1 Slope
½" bar
¼" bars
Counterfort
3'0"
7'0"
¼" bars 21" o.c.
4×4 ONE END.
CONCRETE - 4.31 C.Y.
SQUARE TWISTED STEEL BARS
TWO ½ BARS 5'4" LONG, ONE ½"-4'10" LONG, FOUR ½"-6' LONG, FOUR ½"-9'6" LONG, FOUR ¼" BARS 5'4" LONG, TWO ¼"-4'10" LONG, TWELVE ¼"-2' LONG
WEIGHT OF ½" BARS 65.88 lbs. - WEIGHT OF ¼" BARS 11.72 lbs.

FIG. 7.

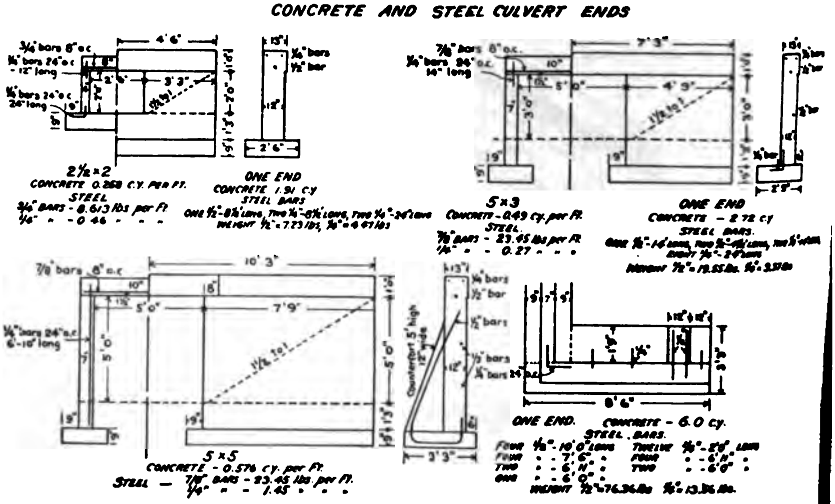
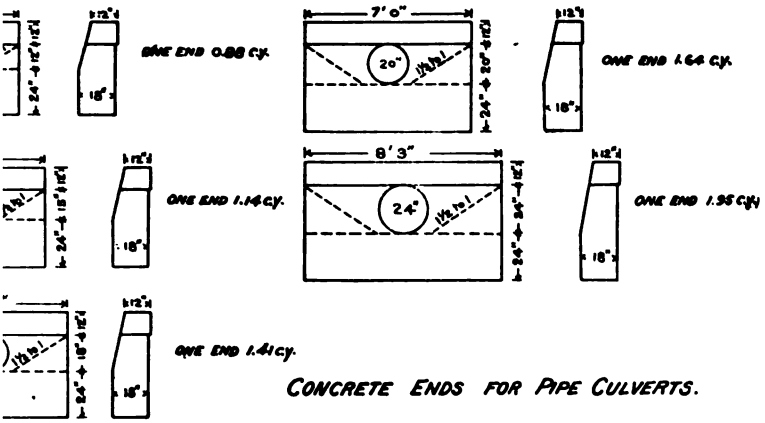
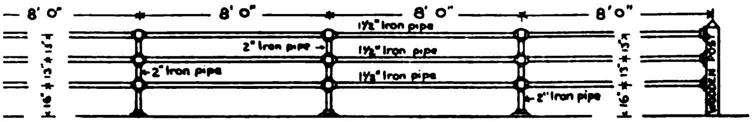

CONCRETE AND STEEL CULVERT ENDS
¾" bars 8" o.c.
¼" bars 24" o.c. - 12" long
¼" bars 24" o.c. 26" long
4'6"
3'3"
1½ to 1
2'6"
2½×2
CONCRETE 0.258 C.Y. PER FT.
STEEL
¾" BARS - 8.613 lbs per Ft.
¼" " - 0.46 " " "
ONE END
CONCRETE 1.91 C.Y.
STEEL BARS
ONE ½"-8½' LONG, TWO ¼"-8½' LONG, TWO ¼"-26" LONG
WEIGHT ½" = 7.73 lbs, ¼" = 4.47 lbs
⅞" bars 8" o.c.
¼" bars 24" o.c. 14" long
7'3"
5'0"
4'9"
1½ to 1
2'9"
5×3
CONCRETE - 0.49 C.Y. per Ft.
STEEL.
⅞" BARS - 23.45 lbs per Ft.
¼" " - 0.27 " " "
ONE END
CONCRETE - 2.72 C.Y.
STEEL BARS.
ONE ½"-14' LONG, TWO ½"-4½' LONG, TWO ½" ...
EIGHT ¼"-2'6" LONG
WEIGHT ½" = 19.55 lbs. ¼" = 2.37 lbs.
⅞" bars 8" o.c.
¼" bars 24" o.c. 6'-10" long
10'3"
5'0"
7'9"
1½ to 1
Counterfort 5' high 12" wide
¼" bars
½" bar
½" bars
3'3"
5×5
CONCRETE - 0.576 C.Y. per Ft.
STEEL - ⅞" BARS - 23.45 lbs. per Ft.
¼" " - 1.45 " " "
8'6"
ONE END.
CONCRETE - 6.0 C.Y.
STEEL BARS.
FOUR ½"-10'0" LONG TWELVE ¼"-2'6" LONG
FOUR " - 7'6" " FOUR " - 6'11" "
TWO " - 6'11" " TWO " - 6'0" "
ONE " - 6'0" "
WEIGHT ½" = 76.36 lbs. ¼" = 13.36 lbs.

FIG. 8.



CONCRETE ENDS FOR PIPE CULVERTS.

FIG. 9.



IRON PIPE FENCE.

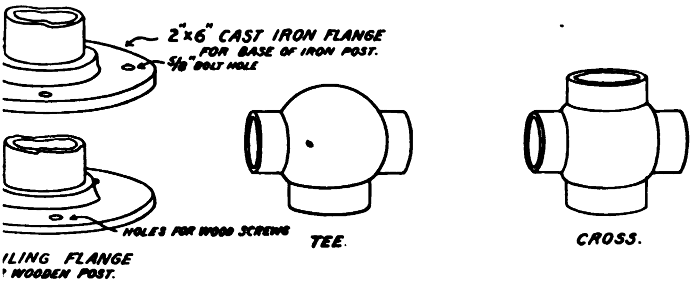


FIG. 10.

SAN FRANCISCO

Issued December 11, 1908.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 339.

ALFALFA.

BY

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1908.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., September 4, 1908.

Sir: I have the honor to transmit herewith and to recommend for publication as a Farmers' Bulletin, to supersede Farmers' Bulletin No. 215, entitled "Alfalfa Growing," the manuscript of an article entitled "Alfalfa," prepared by Mr. J. M. Westgate, Assistant Agrostologist, in Charge of Alfalfa and Clover Investigations in the Office of Forage Crop Investigations of this Bureau, under the direction of the Agrostologist in Charge.

The rapid extension of the alfalfa area in almost every State of the Union has been stimulated by the publications of the Department of Agriculture and those of the State agricultural experiment stations, as well as by the agricultural press. This condition has led to an increasing demand for full information concerning the best means of producing this crop, especially in sections where it is not already well established. The conditions outside of the recognized alfalfa districts are usually unfavorable to the successful production of alfalfa until the natural drawbacks are all overcome. These unfavorable conditions are generally those incident to the humid climate of the East or the lack of sufficient rainfall in the West. A large proportion of the alfalfa seed sown in sections where alfalfa is not a staple crop has been practically wasted owing to the lack of proper understanding of the special requirements of the young plants. This bulletin has been prepared quite as much to point out where and under what conditions alfalfa will probably fail as to indicate the sections and conditions under which success may be expected.

Besides drawing freely upon the publications of the State agricultural experiment stations and the experience of prominent alfalfa growers, there have also been available a considerable number of data derived from the cooperative experiments of the Bureau of Plant Industry carried on with farmers in all parts of the country during the last three years.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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    Irrigated sections
        Methods of irrigation
    Semiarid regions
    Eastern Oregon and eastern Washington
Some alfalfa dont's

ILLUSTRATIONS.

FIG. 1. Map of the United States showing the distribution of alfalfa in 1899
2. Alfalfa plant in early bloom
3. Homemade seed tester
4. Seeds of alfalfa and common impurities
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ALFALFA.

HISTORY AND PRESENT DISTRIBUTION OF ALFALFA.

The original home of alfalfa appears to have been southwest of
ntral Asia, but from there it has been carried to practically every
rt of the world where agricultural pursuits are important. It is
w one of the staple forage crops of every continent of the Old
orld and easily takes front rank as the most important leguminous
age crop of the Western Hemisphere. The name "alfalfa" is of
abic origin and means "the best fodder." The southern European
me of "lucern" was formerly applied to the plant in the eastern
rt of the United States and in Utah, but this name has practically
en way to the name "alfalfa," under which it was introduced by
Spaniards.

The Persians were apparently the first nation which grew this
nt. They took it with them when they invaded Greece about 490
C. The object of this introduction appears to have been to pro-
le forage for the horses and cattle upon which their armies de-
nded. Alfalfa was introduced into Italy during the first century
D. Such early Roman writers as Virgil and Pliny give what may
l be regarded as excellent instructions regarding the handling of
alfa fields. The introduction of alfalfa into Spain was probably
ing the Moorish invasion in the eighth century A. D. The Span-
ds introduced it into Mexico and South America during the six-
nth century. It is reported to have been carried northward from
Mexico into what is now the southern portion of the United
tes, but it was not until 1854, when it was taken to San Francisco
n Chile, that its rapid extension over the irrigated sections of the
stern States commenced. Its culture has since been extended to
ny of the nonirrigated sections of the West. The more humid sec-
ns of the Great Plains area have proved especially adapted to its
duction. Eastward of the ninety-sixth meridian its culture has
n less successful owing to the presence of less favorable condi-
ns of soil and climate.

The history of alfalfa in the Eastern States runs back for at least
o centuries, as the colonists made repeated attempts to establish it.

Under the name of "lucern" it had been introduced into England about 1650. The attempts on the part of the American colonists to establish it were unsuccessful. The limestone region of central New York probably constitutes the area of its longest continued culture in any section of the East. In South Carolina there is a field reported to be seventy-five years old. Alfalfa has also been grown locally in most of the Eastern States for many years. The black prairie soils of Alabama and Mississippi are proving especially adapted to alfalfa. The successful districts have usually been the somewhat limited areas of limestone soils where the conditions are especially suited to the plant. The recent efforts looking to its further extension throughout the East and South indicate that the chances of success increase greatly as the special requirements for its production are understood and provided for.

ALFALFA IN THE UNITED STATES.

Alfalfa is the staple leguminous forage crop throughout the western half of the country. Its distribution, as compiled from the census of 1899, is indicated in the accompanying map (fig. 1). Each dot represents 1,000 acres in the region where the dot is located. For this reason only the sections of rather extensive alfalfa production are shown, as counties having less than 1,000 acres are not dotted. The acreage east of the one-hundredth meridian has probably more than doubled since the last census was taken. Its rapid extension in

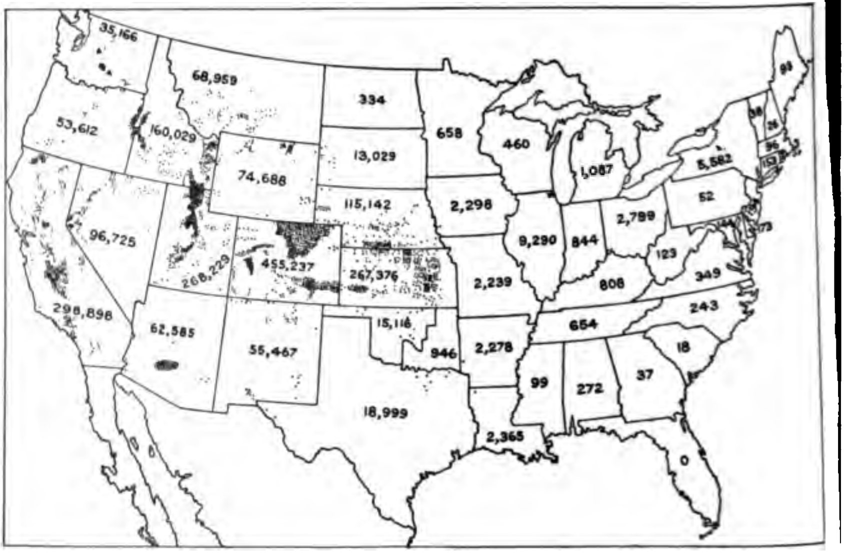

FIG. 1.—Map of the United States showing the distribution of alfalfa in 1899. The numerals indicate the acreage in each State. The dots show the location of the alfalfa sections.

f the West is indicated by the fact that in Kansas the as- reports in 1891, when alfalfa was first listed separately, showed acres, while in 1907 743,050 acres were reported. In the arid s on the areas which have been brought under cultivation in st ten years alfalfa has been extensively planted.

DESCRIPTION OF ALFALFA.

accompanying illustration (fig. 2) indicates the general ap- ce of the plant. It may briefly be described as being a deep- , long-lived herba- forage plant belong- the botanical family inosæ, or pod-bear- nts. Its flowers are clover shaped, and in compact oblong s, or clusters. The are small, slightly and spirally coiled or three turns. The -shaped seeds are one-twelfth of an ng, and several are ed in each pod.

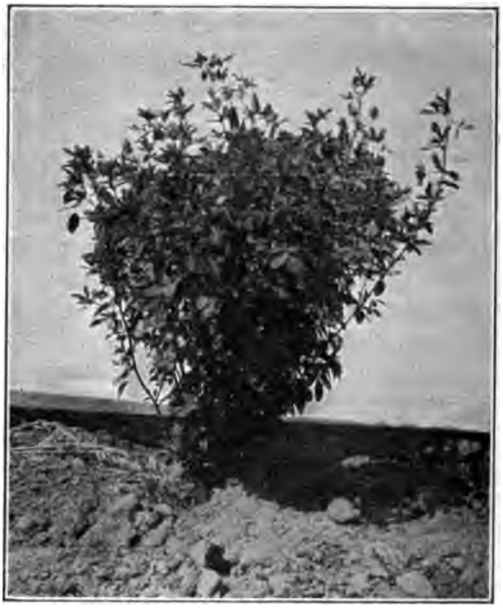

FIG. 2.—Alfalfa plant in early bloom.

of the most im- t characteristics of is its long tap- ften extending 15 e feet into the soil. nables the plant to tores of plant food in the soil which can not be secured by the ry shallow-rooted field crops. This long taproot is also of importance in sections of limited rainfall, as by this means nt is enabled to withstand extremes of drought which would ise be fatal.

DAPTABILITY OF ALFALFA TO VARIOUS CONDITIONS.

wide distribution of alfalfa throughout the world indicates a able adaptability to various climates and conditions. So far ate is concerned alfalfa can be grown in every State in the It is, however, very exacting in the humid sections as to soil eatment. It is grown below the sea level in southern Califor- d at altitudes exceeding 8,000 feet in Colorado. Under proper ion it yields abundant crops in the deserts of Arizona, which are among the hottest in the world. The hardy strains are able to withstand the severe winters of the North Central States. It is raised without irrigation in semiarid sections where the rainfall is only 14 inches a year, and also in the Gulf States where the annual rainfall may amount to 65 inches. A rainfall of 36 inches a year is ample for this crop, and an amount in excess of this is usually a detriment. In moist climates the soil is frequently sour, and the clay soils especially are apt to be too poorly drained. In such a climate weeds and fungous diseases prove much more injurious than under less humid conditions. Although the adaptability of alfalfa is great, yet in the areas not perfectly suited to its successful production care is necessary to provide the very favorable conditions required by the young plants in order to overcome the natural drawbacks.

REQUIREMENTS FOR SECURING AND MAINTAINING A STAND OF ALFALFA.

A deep, fertile, well-drained soil rich in lime and reasonably free from weeds is necessary for alfalfa. The lack of any one of these essentials is very apt to be the cause of failure, especially in the Eastern and the Southern States, where alfalfa is at best produced with some difficulty.

A DEEP SOIL USUALLY NECESSARY FOR ALFALFA.

A deep, permeable soil should be chosen if possible, as alfalfa is naturally a deep-feeding plant that usually sends its roots down many feet to obtain the plant food materials and moisture which are out of reach of the shallow-rooted crops. If the soil lacks depth the alfalfa plant is unable to utilize its deep-feeding root system and is less likely to withstand the inroads made by the surface-feeding weeds. The roots can, however, penetrate rather stiff clay soils, and even some of the soils underlain with hardpan. Instances have also been observed in the limestone sections of the Eastern and Southern States where alfalfa was growing successfully on soils underlain at a depth of but 18 inches with limestone ledges.

IMPORTANCE OF A FERTILE SOIL FOR ALFALFA.

Alfalfa, being a leguminous plant, is able through the nodule-forming bacteria within its roots to add nitrates to the soil and in this way increase its fertility to that extent. Since large yields of alfalfa draw on the soil rather heavily for the other elements of soil fertility, it usually requires the richest and best-drained soil the farm affords, and if successful will bring returns to justify the use of this land. There is risk, however, in selecting bottom lands for alfalfa, both on account of their failure to drain promptly and owing to the danger from weeds on such soils. In the East it is usually best to develop the fertility of some of the higher rolling land and seed this to alfalfa.

West of the Mississippi River the soils are usually fertile enough for alfalfa without the use of any fertilizer. In the East and South, however, they usually require some artificial treatment to bring them up to the proper degree of fertility before alfalfa can be safely planted. This result may be brought about by the plowing under of some green-manure crop, the application of commercial fertilizers, or the spreading of barnyard manure.

Barnyard Manure for Alfalfa.

Well-rotted barnyard manure[a] is usually the most satisfactory fertilizer for alfalfa. Fresh manure is apt to carry large numbers of weed seeds; therefore, if necessary to use it, the application should be made to the preceding crop. This will give time for the germinating weed seeds to be destroyed by the cultivation of the preceding crop or by the stirring of the ground incident to the preparation of the seed bed for the alfalfa.

Green-Manure Crops for the Prospective Alfalfa Field.

Green-manure crops[b] are especially efficient in increasing the humus content of the soil, and this is exactly what many soils require if alfalfa is to be raised upon them. In the South cowpeas, crimson clover, vetches, and even bur clover are successfully used. In the States farther north crimson clover, cowpeas, soy beans, and vetches may be utilized. It is usually best to follow the green-manure crop with some clean-culture crop before seeding the land to alfalfa, as the decaying vines induce acid conditions in the soil that are unfavorable to the alfalfa plants.

Commercial Fertilizers for Alfalfa.

If barnyard manure is not available and if there is not time for the utilization of green-manure crops, it is necessary to apply commercial fertilizer liberally to any soil that may be lacking in fertility. This fertilizer should be reasonably rich in phosphoric acid and potash, but may be poor in nitrogen. However, the kind and amount of fertilizer necessary vary greatly with the soil and section, and exact recommendations can not be made. The State agricultural experiment stations of most of the Eastern and Southern States have made experiments with various fertilizers for alfalfa. It is suggested that the methods outlined under the heading "Need of experimentin first" be used to determine the best formula for any particular

---

[a] See Farmers' Bulletin 192, entitled "Barnyard Manure."

[b] See Farmers' Bulletin 278, entitled "Leguminous Crops for Green Manuring."

NECESSITY FOR A WELL-DRAINED SOIL FOR ALFALFA.

In the humid sections of the country it is especially importan provide a well-drained soil for alfalfa. In the irrigated districts problem of drainage to prevent or reduce the accumulation of a is often serious. In the regions of heavy rainfall natural drain must be provided. It has been found that alfalfa requires much m complete drainage of the soil than do other field crops. Where underdrains are unable to carry off the rainfall rapidly enough prompt drainage, it is sometimes the practice to backfurrow, lea the dead furrows at intervals of a rod or less. This permits the w to run off quickly in the event of heavy rains.[a]

Alfalfa is often killed by overflows from streams. During growing period it will not usually withstand more than twenty-f hours of complete submergence or more than forty-eight hours partial overflow. During the dormant period of winter, howe fields have been known to remain under flowing water for two we without serious injury.

A WELL-LIMED SOIL ESSENTIAL FOR ALFALFA.

No other forage crop requires so much lime in the soil as d alfalfa. It is apparently necessary that the soil acidity be neutr ized by the lime and that there be also an excess for the actual of the plant. In one test an analysis was made of the mineral co stitutents of certain crops. The percentage of lime in the alfa ash was 34.9, while red clover had but 20.6 per cent, and timot had only 4.7 per cent. Throughout the East and South alfalfa most easily produced on the limestone soils. Even these soils oft require liming for the best success of the alfalfa, as the rains te to leach the lime out of the surface layers of the soil.

Liming Soils.

It may be safely assumed that if a soil ever requires liming it wi require it for alfalfa. The litmus test for acidity of the soil may b used, but this is not always satisfactory. The most reliable metho is the one outlined under the heading "Need of experimenting a first," page 20. The only drawback to this method is that it re quires a year's time. It is usually best to apply the lime the seaso previous to sowing the alfalfa, as this allows time for the lime t become thoroughly incorporated into the soil. There are several different forms of lime on the market. As a general rule it is be to purchase that form which will mean the most actual lime for the money outlay. Ground unburned limestone is proving satisfactory in many sections. Nearly twice as much of this as of the fresh-burned lime is required. Under normal conditions a ton of ordinary lump or ground lime is usually applied to an acre.

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[a] See Farmers' Bulletin 187, entitled "Drainage of Farm Lands."

IMPORTANCE OF A WEED-FREE SOIL FOR ALFALFA.

Young alfalfa plants are very tender and are apt to be killed by weeds during their early stages of growth. For this reason it is essential that the land be as free from weeds as possible. This condition can be brought about by raising some cultivated crop for two or three seasons previous to planting alfalfa. The same result can also be secured by seeding the land successively to crops, such as cowpeas, which naturally prevent the growth of weeds. If a weedy soil must be used, the land should be plowed several months before the alfalfa is seeded and the successive crops of germinating weeds destroyed by frequent harrowing. Weeds are especially harmful to spring-seeded alfalfa, and for this reason spring seeding should be avoided and late summer or early autumn seeding practiced in all sections where this can be done.

CROPS WHICH MAY PRECEDE ALFALFA.

The time of year that any given crop may be harvested and the land prepared for alfalfa is an important factor in choosing the crop to precede alfalfa, which usually requires seeding at a certain definite time in any given locality. In sections where late summer seeding of alfalfa is possible the early-maturing truck crops, such as early potatoes, enable one crop to be secured that season and still allow time for the preparation of the land for alfalfa. In addition to this the clean culture given the truck crop will tend to rid the field of weeds and will make plowing unnecessary. The residual effect of the heavy fertilizer applications which must be made for the truck crop will usually suffice for the alfalfa. Except in the extreme North small-grain stubble can usually be worked up in time for late summer seeding. This is especially true of oats.

Clean-culture crops, such as corn in the North and cotton or tobacco in the South, are useful in ridding the land of weeds. As in the case of truck crops, a heavy application of manure may be given these crops and the culture given them will destroy any weeds that may have been introduced with the manure. It is usually impossible in the sections indicated to get such a crop as corn off the land in time for the late summer seeding of alfalfa. In such cases a green-manure crop, such as hairy vetch or common clover, may be seeded in the fall, cut for hay the following spring, and the stubble p in preparation for alfalfa.

In the North Central States where spring or early summer s is necessary, it is sufficient that corn-stubble land be disked an rowed for alfalfa. A small-grain crop may also follow the clea ture crop and immediately precede the alfalfa in sections whe stubble can be plowed under in time for the seeding of the a Sod or pasture land may usually be plowed in the spring and for alfalfa by late summer seeding in the Eastern States. I Great Plains area it is sometimes the practice to break the sod fall and by repeated diskings bring the land into condition for s the alfalfa by spring.

PREPARING THE SEED BED.

The tender nature of the young alfalfa plants requires that tl be in excellent tilth at planting time. The seed bed should be f top but thoroughly settled. The young taproot of the alfalfa strikes down immediately and is apt to be seriously injured encounters a layer of loose dry soil at the bottom of the old fu As a general rule about six weeks are required for plowed land t tle enough for alfalfa seeding. It is sufficient, however, with soils that they be disked instead of plowed. Less time is requir the disked land to settle and the operation is much less exp than plowing.

It is important that the preparation be uniformly good. s poorly prepared spots are apt to fail. These bare places forı centers from which weeds may spread and ultimately destro whole stand. Summer fallowing is often practiced in the sen regions to conserve sufficient moisture for the germination of th at planting time. This method is also effective in any sectio ridding the ground of weeds.

Preparation of Sandy Ground.

It is often difficult to establish alfalfa on soils that are so sandy they drift when bare. The young unprotected alfalfa plant very apt to be cut off by the drifting sand unless special precau are taken. This danger may be avoided by applying a light dressing of straw or coarse manure just after seeding. An method is to drill the alfalfa into the high-cut stubble of cane. or millet; or the alfalfa may be seeded in a thin young stand of grain, such as oats, which makes a rapid early growth and thus tects the seedling alfalfa plants.

SELECTION OF SEED.

tion of the seed is an important matter. The original
e seed, its vitality, and its impurities should each receive
n. Experiments indicate that it is not harmful to sow
own seed in the South, but southern-grown seed should
led in the Northern States on account of danger from
g. It is usually desirable to secure samples from more
urce and test them as to germination and purity before
.[a] It is not a difficult undertaking to make a home test of
illustrated in figure 3.

demand for alfalfa seed in this country has for some time
e supply, there is very little old seed on the market. The
f perfectly fresh seed
nportant, as tests have
samples 5 to 7 years
ry little of their ger-
ower. The loss of vi-
to age is generally in-
the seed turning a
wn. The greatest care
taken to get seed free
gerous weeds. (See

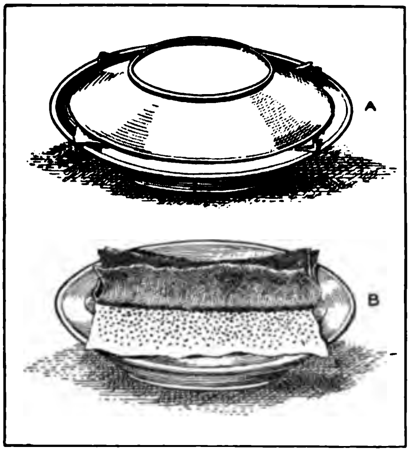

FIG. 3.—Homemade seed tester. A, closed; B, open.

nerally advisable to
amples the winter be-
ed is to be sown. It
npossible in the rush
before seeding to pur-
from the same lot after
ncident to having the germination and purity tests made.
firms will book orders for certain lots of seed "subject to
germination and purity tests." This practice should be
common, however, than it is at present, and will doubtless
eral when there is a sufficient demand for it on the part of

TIME OF SEEDING.

of seeding alfalfa varies in the different sections of the
t late summer seeding is usually best in the East and

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ers' Bulletin 194, entitled "Alfalfa Seed," where a full discussion
ities and adulterants of alfalfa seed is given. The United States
of Agriculture and many of the state agricultural experiment sta-
eady to make examinations of seed for purity and germination free

South. The general principle underlying the time of seedi
sow as far in advance as possible of what promises to be t
trying season for the young plants. Spring seeding is the ru
irrigated and semiarid sections of the West. It is also prefe
Minnesota, Wisconsin, and the Dakotas, where any but sp
early summer seeded stands are very apt to winterkill. Fall
is sometimes practiced in the extreme Southwest, and late
seeding may be nece
times in the Souther
when drought or ot
favorable condition
prevented fall seedi

The weeds of mid
constitute the worst
to the young stand
falfa in the humid
of the country, exc
extreme north, wh
danger is exceeded
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Wherever possible
humid sections of th
try late summer
should be practiced
advantage of this
seeding over that o
spring or fall is
early-maturing crop
removed in time for
the weeds of midsum
avoided, and ample
given for the makin
strong growth to
winterkilling and th
ing of the ground
spring.. The large gr
the plants possible dur
early fall also enable
to make a rapid early growth the following spring. On this
the alfalfa is able to resist much better the inroads of weeds
it had been seeded the previous fall or during the same spring
fig. 5.) A fair yield of hay is secured the season after seedi
in this way there is not the loss of the use of the land for a ye
likely to be the case with spring or fall seeding.

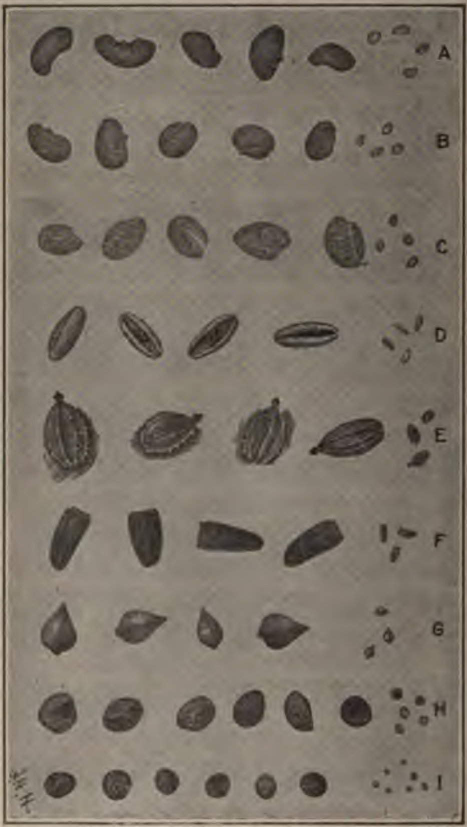

FIG. 4.—Seeds of alfalfa and common impurities. (Enlarged; natural size at the right.) A, alfalfa; B, yellow trefoil; C, sweet clover; D, buckhorn; E. wild carrot; F. wild chicory; G, curled dock; H, large-seeded dodder; I, small-seeded dodder.

METHODS OF SEEDING.

The manner of seeding varies considerably in the different sections, but the various methods agree in that it is necessary for the seed to be covered and not sown on the surface of the ground, as is sometimes done with grasses and clovers. Alfalfa may be planted with a drill or seeded broadcast with a hand seeder or wheelbarrow seeder, or by hand. It is usually best to sow half the seed one way across the field and the other half at right angles to the line of the first sowing.

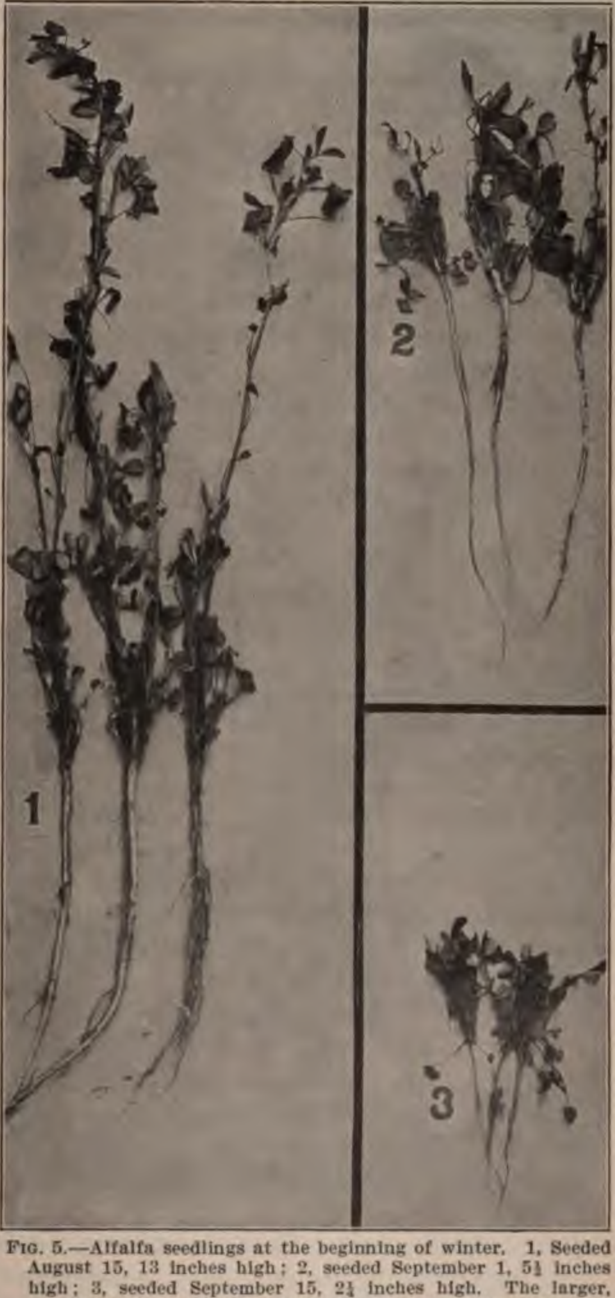

FIG. 5.—Alfalfa seedlings at the beginning of winter. 1, Seeded August 15, 13 inches high; 2, seeded September 1, 5½ inches high; 3, seeded September 15, 2¼ inches high. The larger, early-seeded plants are much better able to withstand the winter than are the small, late-seeded ones.

The depth of planting depends on the soil conditions. Covering from three-fourths to 1 inch deep is usually sufficient on clay soils, but an inch and a half is necessary on sandy soils or in the semiarid sections, where deep covering is required to insure sufficient moisture for the germination of the seed. When seeded broadcast, a light harrow, weeder, or brush is used to cover the In case the soil is light it may be rolled, but this is not usuall visable, as the soil is more apt to become dried out before the p can become established. A smaller quantity of seed is used wh is drilled. If a grain drill is used, the amount seeded may be lated by the use of leather thongs to reduce the feed.

RATE OF SEEDING.

The quantity of seed required per acre is much greater in humid sections than in the semiarid and irrigated sections of country. In the West fair stands have been secured with as litt 1 to 5 pounds of seed per acre, but this has been under perf ideal conditions. Good stands from 5 pounds of seed to the are not unusual in the West. Twenty pounds per acre is the am usually recommended, however, and even this must be incre where the danger from weeds is serious and it is necessary tha alfalfa plants cover the ground from the start to prevent the w from becoming established. A pound of ordinary alfalfa con about 220,000 seeds. As there are 43,560 square feet in an acre, pound seeded would give about 5 seeds to the square foot. At the of 20 pounds per acre each square foot would receive 100 Many of these fail to grow, and the young plants meet with accidents. Counts in old alfalfa fields have shown from 1 plants per square foot, practically equal yields being secured fro A year-old field in Virginia was found to contain 20 plants t square foot.

The following recommendations as to the rate of seeding are for the different sections of the country: Atlantic and Sout States, 24 to 28 pounds per acre; States east of the ninety-eighth ridian and west of the Appalachian Mountains, 20 to 24 pounds; arid sections of the Great Plains, from 5 to 15 pounds, dependin the average rainfall; 15 pounds is commonly seeded in the irrig sections by experienced growers.

USE OF A NURSE CROP.

In the East and the South and in the semiarid sections of the a nurse crop usually proves disastrous to alfalfa, often resultin the complete destruction of the stand. In sections where it ca used alfalfa usually succeeds in spite of the nurse crop rather tha reason of it. In the irrigated sections of the West a nurse cro often used, the two crops being seeded together in the spring.

In the extreme Southwest barley is sometimes seeded with alf in the fall. In the States bordering on Lake Michigan a half see of beardless barley is often a success as a nurse crop for alfalfa.

even in this section it is generally recommended that the alfalfa be seeded alone in midsummer. In sandy soils a very light seeding of small grain as a nurse crop is sometimes used to prevent the sand from blowing and injuring the young plants. In all cases the nurse crop, if ever used, should be cut as soon as it shows signs of injuring the alfalfa plants.

Sometimes a successful stand may be secured in Ohio and neighboring States by seeding in corn at the last working. This method is apt to prove a failure in case of a dry season.

INOCULATION FOR ALFALFA.

Throughout the western half of the United States the soil appears to be naturally supplied with the proper bacteria for the formation of the root tubercles. In the eastern part of the country, however, where the soil conditions are less favorable to the growth of these bacteria, it is nearly always necessary to supply them at the time of seeding. This inoculation may be supplied either by scattering soil from a successful alfalfa field or in the form of artificial cultures.

Inoculation by Soil Transfer.

Although possessed of some disadvantages, inoculation by means of soil from a successful alfalfa field will nearly always produce the desired results. It is essential that care be taken to avoid the introduction of seeds of noxious weeds or harmful plant diseases. The bulkiness of the 300 to 800 pounds of soil necessary for an acre makes it advisable to secure the soil from a field as near by as possible.

It has been found that soil from around the roots of the sweet clover (*Melilotus alba*) is quite as effective as alfalfa soil. In most sections of the country this plant may be found growing wild in scattered clumps. In the South, where bur clover occurs, soil from around its roots may be used with good results. The soil may be mixed with the seed and sown with it. It may also be drilled or broadcasted separately. If broadcasted, the soil should be scattered on a cloudy day or toward evening and immediately harrowed in, as sunshine is harmful to the germs.

If the soil has to be freighted considerable distances, it is usually advisable to use but 200 or 300 pounds of soil per acre, but this should be mixed with several times its weight of ordinary soil to facilitate even scattering. If the soil is difficult to secure, it may be best to seed a very small area the first season, taking special precautions to have it thoroughly inoculated. This will then furnish an abundance of soil for inoculating a larger area the following season.

It can not be urged too strongly that inoculation is absolutely essential to the successful production of alfalfa. There are very few soils outside the alfalfa districts that do not require inoculation, and it may be taken as a general rule that all other soils must have the inoculation supplied in order to grow alfalfa successfully. A few soils, however, especially those upon which sweet clover grows naturally, seem able to produce successful stands without artificial inoculation. These, however, are the exception rather than the rule.

Inoculation by Pure Cultures.

The artificial cultures supplied by the United States Department of Agriculture are fully explained in the Farmers' Bulletin on the subject.[a] These cultures are sent out in hermetically sealed tubes. The contents are mixed with clean water, and certain chemicals included with the outfit are added to the solution to form the food supply of the germs while they are multiplying. When the germs have increased sufficiently in number the solution becomes of a faint milky color. It is then applied to the seed. The seed should be dried in a shaded place and sown as soon as possible. The advantages of the artificial cultures lie in the greater ease of transportation and application as well as in the absence of the danger of introducing plant diseases or harmful weeds.

Inoculation produced by the cultures, in case it is successful, seems to be in every way as efficient as when the soil method is used. Fewer failures are reported in the case of the soil-transfer method, but the reason for this has not been definitely determined. It has been found that successes are more apt to follow inoculation with pure cultures if the seed is sown immediately after the seed has been dried after having been inoculated. There is some evidence accumulating to indicate that the germs in the pure cultures when they do survive are superior to those normally found in the alfalfa soil. It is suggested, therefore, that both the soil-transfer method and the artificial cultures be used.

TREATMENT THE FIRST SEASON.

If seeded in the late summer or early autumn, alfalfa will require no treatment that autumn unless a growth of more than 12 inches is made before cold weather. If this occurs, the plants should be clipped back so that they will go into the winter with 8 or 10 inches of growth. In this condition they will be best able to withstand the winter and will be in excellent shape to renew their growth the following spring. The first cutting of hay should be secured in the late spring.

If, on the other hand, the seed has been sown in the late fall or in the spring, but little more than a clipping can be secured in the late spring or summer. This clipping should be made preferably when the basal shoots start and should be made 3 or 4 inches high, as the plants will be slow in recovering if cut too low. It may be necessary to cut at some other time than the ideal time indicated, as, for instance, when the weeds threaten to choke out the young plants, when the blossoms appear, or when the plants begin to turn yellow. Except in the latter case the clippings are usually left on the ground as a mulch. If the plants have turned yellow owing to some disease, the clippings should be raked up and removed. A top-dressing of nitrate of soda will sometimes invigorate the diseased plants. The same statements govern subsequent cuttings the first summer, except that the growth is usually too heavy to be left on the field.

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[a] See Farmers' Bulletin 315, "Progress in Legume Inoculation."

TREATMENT THE SECOND SEASON.

Ordinarily no treatment is required during the second season, except to cut the hay when the plants are about one-tenth in bloom, or, better, when the new crown or basal shoots are starting. It is important to get the hay off the field as soon as possible, in order to allow the new growth to commence uniformly over the field. If the windrows or cocks are allowed to remain too long on the ground, the alfalfa plants will be smothered out and then bare spaces will form the centers from which weeds will spread.

No pasturing should be allowed during the first or second seasons, as the crowns have not become sufficiently well developed to withstand the effect of trampling. About three-fourths to a full crop may be expected the next season after late summer seeding in the humid regions. Nearly a full crop is usual the second season after spring seeding if the weeds of the first summer have not seriously injured the stand.

TREATMENT DURING SUBSEQUENT SEASONS.

As long as an alfalfa field shows a perfect stand, with no tendency to run to weeds, it is not customary to give the field any special treatment. If the weeds begin to prove troublesome, it is advisable to disk the alfalfa after cutting. This process loosens up the soil and aerates it, which is decidedly advantageous to the alfalfa. The taproots of the alfalfa plants are not usually injured by this practice if the disks are set nearly straight, while the weeds are to a great extent destroyed. A spike-toothed harrow may follow the disk to level the ground.

In the East an implement known as an alfalfa renovator is meeting with success. It is a modification of a disk harrow with spike teeth on the disks. It is adapted to loosening up the ground and destroying the weeds without serious injury to the alfalfa. Many growers who have a large acreage of alfalfa disk their fields each season. Disking, however, is apt to be destructive to the alfalfa in sections where the alfalfa does not thrive.

If there is a considerable growth of fall weeds or grasses these may be burned off the following spring before the alfalfa starts. The field should be burned before a strong wind to avoid injury to the alfalfa crowns. In sections where soils require liming, it is sometimes advantageous to make an application of lime either in the spring or after the first cutting. Slaked lime may be used, but ground unburned limestone is preferable, as this will not injure the alfalfa plants. A top-dressing of well-rotted or weed-free barnyard manure may be made during the early winter with advantage on most of the soils in the eastern half of the United States.

DRAWBACKS OF ALFALFA.

Valuable as alfalfa is, it is not without its drawbacks and weak points. It is difficult to establish, especially in the Eastern States, where red clover is generally successful. The methods customary for the raising of red clover, however, do not apply to alfalfa and much has to be learned by experience as to the special requirements of the alfalfa plants.

The first cutting in late spring comes at a time when heavy rains are apt to interfere with its proper curing. It does not cure at all readily and this point makes a good quality of hay extremely hard to get, especially from the first cutting. The bright green hay so common in the irrigated sections is almost never seen in the humid sections, owing to injury from rain. Alfalfa does not reseed itself, and although the individual plants may live for years, when once a plant dies its place is taken not by other alfalfa plants but by weeds.

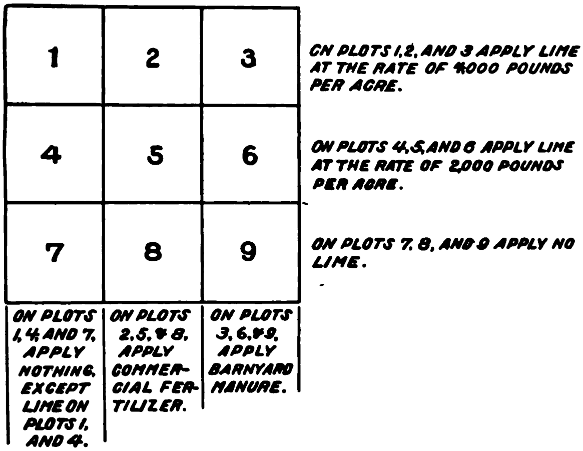
On farms where the production of alfalfa is a side issue, the three or four cuttings of hay procured during the season are apt to come at a time when the normal work of the farm is directed along other lines. In such cases attention can not be given to the alfalfa work at the proper time without handicapping the major lines of farm work.

Furthermore, when pastured by cattle and sheep, bloating is likely to occur, with the possibility of the loss of valuable animals. The seed is expensive and the cost of getting the ground in satisfactory condition is quite considerable, thus working a hardship if the stand is not a success, as is too often the case.

NEED OF EXPERIMENTING AT FIRST.

Perhaps no other crop requires such a variety of different treatments, depending upon the special locality in which it is grown. alfalfa. For this reason early attempts are likely to be failures.

consequently should be made upon a very small scale. Many have succeeded in producing profitable crops of alfalfa only after sowing it for several years in succession.


1
2
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4
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6
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8
9
ON PLOTS 1, 2, AND 3 APPLY LIME AT THE RATE OF 4000 POUNDS PER ACRE.
ON PLOTS 4, 5, AND 6 APPLY LIME AT THE RATE OF 2,000 POUNDS PER ACRE.
ON PLOTS 7, 8, AND 9 APPLY NO LIME.
ON PLOTS 1, 4, AND 7, APPLY NOTHING, EXCEPT LIME ON PLOTS 1, AND 4.
ON PLOTS 2, 5, & 8, APPLY COMMERCIAL FERTILIZER.
ON PLOTS 3, 6, & 9, APPLY BARNYARD MANURE.

FIG. 6.—A suggested outline for experiments with alfalfa.

It is suggested that the area seeded at first be small, and that it be divided into a number of subdivisions, each receiving a different treatment; for instance, in the humid sections in regard to the application of fertilizers and lime. The accompanying diagram (fig. 6) indicates an experiment adapted to the eastern half of the United States. A more simple form of this experiment is shown in figure 7. This calls for the application of lime to the northern half of the area and no lime to the southern half. The eastern half should then receive manure and the western half no manure. This will make 4 plots to the experiment, instead of 9 as in figure 6. The strips receiving lime and manure may well be wider than the strips not receiving such treatment. This will reduce the size of the check plot which receives neither application and is thus less apt to succeed.

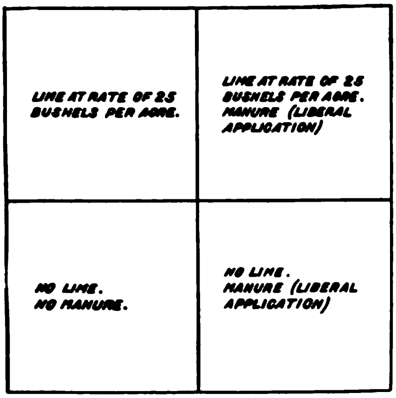
LIME AT RATE OF 25 BUSHELS PER ACRE.
LIME AT RATE OF 25 BUSHELS PER ACRE. MANURE (LIBERAL APPLICATION)
NO LIME. NO MANURE.
NO LIME. MANURE (LIBERAL APPLICATION)

FIG. 7.—A suggested outline for simple experiments with alfalfa.

The method, however, is the important feature, and can be modified to suit the prevailing conditions. The idea is to try on the same field at the same time all the different treatments that are likely to prove successful. The treatment giving the best results can be applied to an increased acreage the succeeding season. In this way the experience which would otherwise require a number of seasons to procure can be obtained at the end of the first year.

In the semiarid regions, where the preparation of the soil and the time of seeding are the important factors, the experiments can be formulated along these lines rather than to include the lime and fertilizers which are necessary in the eastern sections. In all cases it is important that a check plot be left that receives no special treatment—that is, only the ordinary treatment—in order to make possible a definite comparison of the effect of the different treatments.

UTILIZATION OF ALFALFA.

ALFALFA HAY.

Probably four-fifths of the alfalfa of the country is utilized in the form of hay. The number of cuttings depends upon the length of the growing season and the varieties and varies from eight and sometimes nine in the extreme Southwest to two in the northern and the semiarid sections. Under favorable conditions three cuttings may be obtained in the northern portion of the country, but in very dry sections one cutting may be all that can be secured in dry seasons. From thirty to forty days of good growing weather are usually required to produce sufficient growth for a hay crop.

Time of Cutting.

The general rule is to cut alfalfa just as it is coming into bloom. Feeding experiments show that the feeding value is highest when the alfalfa is cut in early bloom. Results obtained at the [illegible] Agricultural Experiment Station show that with hay cut when one-tenth in bloom the protein content is 18.5 per cent; when one-half in bloom, 17.2 per cent; and when in full bloom, 14.4 per cent.

Cutting just as the field commences to show the blooms usually gives satisfactory results. It is safer and better, however, to watch for the starting of the basal shoots which are to form the growth for the succeeding crop. In this way the new growth is ready to take immediate possession of the ground and no delay results. On the other hand, if the cutting takes place before these shoots are formed the new growth is delayed until they can be formed. If the cutting be delayed until these shoots have attained any considerable height they will be cut off by the mower to the injury of the succeeding crop. In case, however, dry weather retards the development of the basal shoots until after the plants commence blooming, the crop should be cut at once so as to get the best quality of hay.

Methods of Harvesting.

The methods of harvesting alfalfa hay vary considerably in the different sections of the country. The ideal everywhere, however, is to enable the hay to reach the feed lot or barn with the least possible amount of handling and exposure to the weather. In the West, where the absence of rainfall during the haying season is the general rule, the conditions for curing the hay are nearly ideal. It is the usual practice to start the mowers in the morning and rake the hay into windrows the following day. (See fig. 8.) The hay is then cocked or is stacked or baled direct from the windrows as soon as the hay is sufficiently cured. This is usually within two days after raking if the hay is to be stacked, or three days if it is to be baled. The raking commences as soon as the leaves are wilted, but when the stems are still green. It is cocked when the stems are "half dry." It may be stacked when moisture can no longer be twisted out of a wisp of the hay. It is not in suitable condition for baling, however, until the stems will break under heavy twisting in the hand.

FIG. 8.—An irrigated alfalfa field in the West.

In the humid sections of the country the process of curing the hay is much more difficult, and the cuttings must frequently be delayed for several days on account of bad weather. The operations in this connection are, however, practically the same as in the dry sections, except that more time is required. Stack covers may in some cases prove necessary. A European device which has been locally adopted in this country consists of a three-legged stool upon which the cock is built, thus permitting rapid drying in the event of rain.

Machinery for Making Hay.

In the East it is the practice to use the ordinary haying machinery in the making of alfalfa hay. In the West, however, special machinery which results in decreasing hand labor to a great extent is used. Mowing machines cutting a swath six or eight feet in width are sometimes used on the large alfalfa fields. The rakes are the ordinary dump rakes or, maybe, side-delivery rakes which leave the hay in a continuous windrow parallel with the swath. This is then in proper shape for loading on to the hayrack with a hay loader or for handling with sweep rakes, buck rakes, or " go-devils." At the barn or stack, hay forks or stackers do away with the necessity of hand pitching. With them it is possible to lift from 100 to 500 pounds of hay from the load and place it at any desired place on the stack or in the mow.

Importance of the Leaves for Hay.

One of the dangers to be guarded against in alfalfa hay making is the shattering of the leaves. Only two-fifths of the total weight of the alfalfa plant is in the leaves, yet three-fifths of all the protein is contained in them. In other words, 44 pounds of the leaves contain as much protein as 100 pounds of stems. Analyses show that the leaves are somewhat richer than bran for feeding purposes . Much of the loss of leaves ordinarily occurring during harvesting may be saved by proper attention to the curing operations.

Injury to Hay by Exposure to Rains.

Experiments at the Colorado Agricultural Experiment Station have shown that a considerable proportion of the crude protein in hay is soluble and that as much as 40 per cent may be lost by two weeks' exposure to rains aggregating a total of about one and three-quarters inches. In this particular experiment the protein content of the hay was reduced from 18.71 per cent to 11.01 per cent. This indicates clearly one of the handicaps to the successful production of alfalfa hay in sections of heavy rainfall during the haying season. Even a slight rain destroys the green color of the hay which is so cha[illegible] teristic of the western-grown hay cured without having been wet.

Stacking Hay.

The use of hay forks and stackers throughout the alfalfa dist[illegible] makes it possible to build very large stacks. (Fig. 9.) The large[illegible] of the stacks is a decided advantage, as a smaller percentage of [illegible] hay is exposed to the elements. Alfalfa hay does not shed wa[illegible] readily, and if barn protection or a shed roof is not provided it is commonly the practice to cover the stacks with canvas or with grass hay or millet to shed the water. A load of green alfalfa placed upon the top of the stack will on drying form a good protection to the stack.

alfalfa hay is to be transported any considerable distance. it is ly baled. (See fig. 10.) Otherwise it is fed from the stack or barn.

—Stacking alfalfa in the West. The new crop is stacked on the top of the preceding crop by the use of large hay forks.

baling is done either from the windrow or from the stack. If the windrow care must be taken to have the hay at the proper

).—Baling alfalfa hay. The sweep rake, or "go-devil," is used to bring in the hay from the windrow.

of curing so that it will not be so damp as to heat and spoil or y as to lose its leaves. The ordinary bale weighs about 90 pounds.

Spontaneous Combustion of Hay.

When alfalfa hay is stacked or put away in the barn too g is apt to heat and may in extreme cases become so hot as to ta and burn. In such cases care should be taken to admit no air i heated mass, which will then be unable to burn for lack of o If this heating process is not carried too far it results in what is as brown hay. In this form it is still well relished by stoc apparently loses none of its feeding value.

ALFALFA MEAL.

Within the past few years the manufacture of alfalfa mea alfalfa hay has assumed considerable importance. The meal is put on the market just as it is ground or is mixed with oth centrates, such as molasses, bran, and corn chop. The advant alfalfa meal lie in the fact that it is usually fed with less was the hay; the hay used for the meal is generally of better quali has a higher percentage of protein than the ordinary hay. Ther considerable advantage to be derived from the reduction of charges.

A pound of alfalfa hay does not contain any more nutrimen ground up into meal than it did before, and for feeding in the districts it is doubtful if the advantages pay for the greater the meal. It is, however, a very convenient form for special pu such as city trade and where the product has to be shipped to tance. Alfalfa meal is an excellent feed for poultry.

ALFALFA FOR ENSILAGE.

The readiness with which alfalfa hay may usually be cur utilized renders the making of ensilage from the alfalfa unne except under special conditions. In the humid sections th crop is sometimes ensilaged when the frequent rains in the late prevent its being properly cured as hay. The third cutting is ready for cutting about the time corn is ready for the silo and mixed with the corn silage.

Pure alfalfa ensilage is apt to be slimy, and considerable due to spoiling around the edges of the silo appear to be inev It is necessary to use a deep silo for alfalfa to make possible su pressure to prevent spoiling. The Colorado Agricultural Exper Station found that ensilage made from the whole alfalfa showed of 10.7 per cent, while the chopped alfalfa was damaged to the of 7.3 per cent.

A form of ensilage is made by putting the green alfalfa in stacks and preventing the access of air while the heating proces progress. This method is open to the danger of overheating.

ALFALFA AS A SOILING CROP.

The readiness with which alfalfa renews its growth after cutting, as well as its value as a feed, makes it an ideal soiling for all classes of stock. There is practically no danger from bloat, as is the case when the alfalfa is pastured. The field from which the daily cuttings of green feed are taken should be large enough to be cut over in four or five weeks, as under such conditions the part of the field first cut will be ready for the second cutting by the time the first crop is entirely utilized.

ALFALFA PASTURE.

Alfalfa should never be pastured during the first or second season of its growth. Even an old field of alfalfa should be grazed rather sparingly if a uniform stand is to be maintained. The last crop of alfalfa is frequently pastured off, as other grazing is often short in the autumn. Care should be taken not to pasture too closely in the late autumn, as the plants should be allowed to go into the winter with some growth upon the crowns. This will enable them to withstand the winter better and also to store up reserve food material for a vigorous early growth the following spring. The evil effects of the trampling of the stock while grazing can be overcome by disking to loosen up the compacted ground.

All kinds of live stock may be pastured upon alfalfa. Horses and sheep are more destructive to the stand of alfalfa than are cattle, as they graze more closely. Hogs are apt to injure the stand by rooting unless their noses are ringed. The utilization of alfalfa for hog pasture is in the aggregate probably the most extensive, as nearly every farmer throughout the alfalfa regions makes a practice of this chiefly because it proves to be a very profitable method of utilizing the crop. An average field of alfalfa will support continuously during the growing season about ten large hogs to the acre and enable them to make good gains, especially if a small quantity of grain is fed in addition. The usual custom is to allow 1 pound of grain a day for every hundred pounds live weight of the hogs.

The principal drawback to the pasturing of cattle and sheep on alfalfa is their tendency to bloat. This danger can, however, be reduced to a minimum by proper precautions in not allowing the cattle to go on to the pasture with empty stomachs, especially when the alfalfa is wet.

When the animals become bloated several remedies are usually at hand for the malady. A large bit an inch in diameter may be tied in the mouth, a piece of rubber tubing may be passed through the mouth to the first stomach, or as a last resort the animal may be tapped to allow the escape of the gas. For this purpose a trochar is best, but in the absence of this instrument a small-bladed knife may be used to make the incision about 6 inches in front of and slightly below the left hip bone. A straw or quill may be used to permit the escape of the gas.[a]

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[a] See Special Report of the Bureau of Animal Industry, "Diseases of Cattle."

FEEDING VALUE OF ALFALFA.

Alfalfa is one of the most highly nutritious and palatable of feeds for all classes of farm animals either in the form of green alfalfa or as hay. The following tables indicate the results of experiments to determine the relative value of several different kinds of feeds:

Average percentage composition of alfalfa and other forage crops.[a]

Kind of forage.	Number of analyses.	Water.	Ash.	Protein.	Crude fiber.	Nitrogen free extract.	Ether extract (fat).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Fresh alfalfa	23	71.8	2.7	4.8	7.4	12.3	1.0
Fresh clover	43	70.8	2.1	4.4	8.1	13.5	1.1
Alfalfa hay	21	8.4	7.4	14.3	25.0	42.7	2.2
Clover hay	38	15.3	6.2	12:3	24.8	38.1	3.3
Timothy hay	68	13.2	4.4	5.9	29.0	45.0	2.5
Cowpea hay	8	10.7	7.5	16.6	20.1	42.2	2.2

[a] In part from Henry's "Feeds and Feeding," Appendix.

Average percentage of digestibility of alfalfa and other forage crops.

(Experiments with ruminants.)

Kind of forage.	Number of experiments.	Protein.	Crude fiber.	Nitrogen free extract.	Ether extract (fat).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Fresh alfalfa	2	81	45	76	52
Fresh clover	2	67	53	78	66
Alfalfa hay	28	73	43	66	54
Clover hay	46	55	49	69	53
Timothy hay	26	48	52	63	57
Cowpea hay	2	65	43	71	50

Digestible nutrients in alfalfa and other forage crops.

Kind of forage.	Dry matter in 100 pounds.	Digestible nutrients in 100 pounds.		
		Protein.	Carbohydrates.	Ether extract.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Fresh alfalfa	28.2	3.9	12.7	0.5
Fresh clover	29.2	2.9	14.8	0.7
Alfalfa hay	91.6	11.0	39.6	1.2
Clover hay	84.7	6.8	35.8	1.7
Timothy hay	86.8	2.8	43.4	1.4
Cowpea hay	89.3	10.8	38.6	1.1
Wheat bran	88.1	12.2	39.2	2.7
Shelled corn	89.1	7.9	66.7	4.3

The following table indicates the actual feeding value of eight different kinds of feed, based on the amount of digestible nutrients contained in them. These values are calculated from the figures given in the table just preceding. The values per pound assigned as the basis of calculation are protein, $0.0674; carbohydrates (starches, etc.), $0.0064; ether extract (fats), $0.0112. These figures are merely relative, as the prices of the food elements vary in the different sections and from year to year. It will be noted that the value of alfalfa hay is slightly more than double that of timothy.

Actual feeding value of different feeds based on amount of digestible nutrients.

Feed.	Value per ton.	Feed.	Value per ton.
Fresh alfalfa	$7.00	Timothy hay	$9.80
Fresh clover	5.96	Cowpea hay	19.76
Alfalfa hay	20.16	Wheat bran	22.80
Clover hay	14.12	Shelled corn	20.16

ALFALFA FOR DAIRY COWS.

Dairy cows require high protein feeds in order to produce profitable flows of milk. These can be supplied by feeding nonleguminous roughage and such concentrates as bran and corn meal. Such concentrates are expensive, however, and can be replaced by a feed like alfalfa. Experiments made by the Tennessee Agricultural Experiment Station in regard to the replacing of grain with alfalfa in rations for dairy cows indicated that 1½ pounds of alfalfa will replace 1 pound of wheat bran. The tests showed that with alfalfa hay at $10 a ton and wheat bran at $20 the saving effected by substituting alfalfa for wheat bran is $2.80 for every 100 pounds of butter and nearly 20 cents for every 100 pounds of milk.

ALFALFA FOR BEEF CATTLE.

Alfalfa forms probably the best roughage for fattening cattle, as its lack of bulkiness enables the animals to consume sufficient quantities for rapid gains. It is also very valuable for young growing stock before the fattening period commences.

The Utah Agricultural Experiment Station conducted an experiment extending over a period of five years to determine the quantity of beef produced to the acre from alfalfa hay cut in the different stages of maturity. It was found that hay cut when in full bloom produced 562 pounds of beef annually to the acre, while that cut in early bloom produced 706 pounds. The hay that was not cut until half the blooms had fallen produced only 490 pounds of beef to the acre. At the Nebraska Agricultural Experiment Station 2.41 pounds of beef were produced daily on a full ration of corn and alfalfa, while only 1.48 pounds were produced by a ration of corn and prairie hay.

ALFALFA FOR SHEEP.

Alfalfa is an ideal hay for sheep, but is apt to cause bloat if used as pasturage. It is the custom throughout the mountainous regions of the West to pasture the sheep on the wild grasses in the mountains during the summer and then drive them to the valleys during the winter to be fed on alfalfa hay. As an instance of its value for sheep in the East, the experience of the Wing Brothers, in Ohio, may be cited. Spring lambs cost them $6 per hundred pounds when alfalfa was not used in the ration, as compared with $2.50 per hundred when alfalfa formed the principal part of their feed. It is the practice in the West to cut alfalfa hay for sheep just as it commences to bloom instead of when one-tenth in bloom, as is customary for dairy cattle, or when one-half to two-thirds in bloom if for horses.

ALFALFA FOR HOGS.

Alfalfa is fed to hogs for the most part in the green state, either as a soiling crop or as pasture. The hay, however, constitutes a maintenance ration for hogs during the winter, and when fed on it sows enter the spring farrowing season in excellent condition. Wherever possible brood sows should secure alfalfa at least during the latter portion of the period of gestation.

At the Kansas Agricultural Experiment Station it has been shown that an acre of alfalfa produced 776 pounds of pork during the season. This calculation was made by deducting the probable gain due to the small ration of grain fed in connection with the pasturage. In another experiment it was shown that for every bushel of Kafir corn meal and 7.83 pounds of alfalfa hay the hogs made a gain of 10.88 pounds. When the alfalfa was withheld from the ration the gain was only 7.48 pounds for each bushel of grain fed.

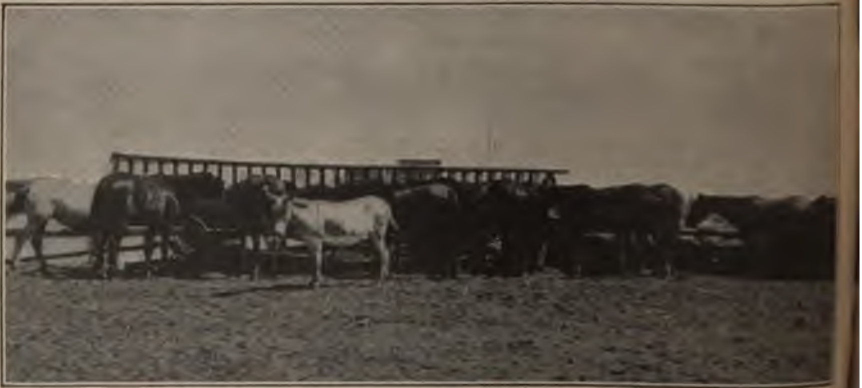

FIG. 11.—A portable alfalfa feed rack which avoids the necessity of unloading the hay in the feed yard. This device is also applicable to other kinds of hay.

ALFALFA FOR HORSES.

Alfalfa may be fed to horses both in the green state and as hay. (Fig. 11.) Instances are on record where horses have performed heavy work during the summer season on nothing but green alfalfa. There is a prejudice on the part of liverymen against alfalfa and in favor of grass hay, owing to the laxative effect of the alfalfa. Many persons hold that the kidneys are unduly stimulated by alfalfa, but this does not appear to be well substantiated by experimental data. On the contrary, there are numerous instances on record where alfalfa hay and green alfalfa have formed a major portion of the ration for the work ing animals of the farm for years without injurious effect. Alfalfa is a most excellent feed for young growing stock, especially horses, but care must be taken to avoid feeding too much hay to colts, as coarseness is apt to be developed.

ALFALFA FOR POULTRY.

Alfalfa makes an excellent feed for all kinds of poultry. They can be allowed the range of an alfalfa field during the summer or it can be cut green and fed to them. In the winter alfalfa meal fed in a mash may be used as a part of the ration with good effect in maintaining the egg production. It is quite as valuable for this purpose as red clover.

ALFALFA FOR BEES.

The development of the honey-producing industry in the West has been practically coincident with the extension of alfalfa culture. Statistics indicate that the heaviest yields of honey per stand of bees are secured in the sections showing the greatest acreage of alfalfa. That the honey is of a good quality is evidenced by its standing in exhibitions of this class of products. The number of times that the alfalfa fields come into blossom during the season makes possible the gathering of successive crops of honey.

ALFALFA IN MIXTURES FOR PASTURE.

Although alfalfa is generally grown alone, there are exceptions to the general practice which indicate that its use in mixtures might profitably be extended in many sections. Alfalfa alone is apt to be a richer feed than is necessary for a steady diet and may well be used in connection with some of the tame grasses.

The tendency of a pure stand of alfalfa to produce bloat appears to be overcome if the stock be allowed access to the ordinary tame grasses. An adjoining field of a tame grass answers the purpose, but it is usually best to seed the alfalfa in a mixture with one or more of the staple tame grasses which succeed in the locality in question. A half of a full seeding of alfalfa is recommended.

In the East orchard grass and meadow fescue are recommended, as these do not spread by underground rootstocks and endanger the stand of alfalfa. Kentucky bluegrass is apt to run out the alfalfa if this grass is used in the mixture in the bluegrass sections. In the Great Plains region west of Missouri and Iowa smooth brome-grass gives good results when used in a mixture with alfalfa, although this grass spreads by underground rootstocks and has a tendency to crowd out the alfalfa, especially when pastured without being cut for hay.

WINTER GRAIN IN ALFALFA FIELDS.

In the Southwest the mild winters and the occurrence of much of the rainfall during the colder months make it possible to seed wheat or barley in a stand of alfalfa after the last cutting and har[illegible] at the proper stage for hay the next spring with the first cuttin alfalfa. The presence of a crop of small grain during the wi months prevents the growth of troublesome weeds, which somet almost ruin the first cutting of alfalfa. This practice has the fur advantage of giving a mixed crop of alfalfa and grain hay, w is regarded as superior to pure alfalfa, owing to the scarcity in section of feeds rich in carbohydrates or starchy matter. ' method is also commendable when for any reason the stand ha come thin, as through the action of field mice. The amount of g to be seeded and disked in depends on the thickness of the stan alfalfa. This practice has been followed for many years in cer parts of the Southwest, although its value does not appear to be ognized to the extent that it apparently deserves.

EFFECT OF ALFALFA ON THE LAND.

Alfalfa acts in a manner similar to red clover and other leg nous crops in increasing the yields of the succeeding crops. roots add nitrogen directly to the soil and are efficient by reaso their deep-feeding habit, bringing up other mineral constituents f the lower layers of the soil and thus rendering them accessible to shallow-feeding crops.

Results at the Wyoming Agricultural Experiment Station show t on irrigated land the effect of alfalfa was to increase the value acre of subsequent crops as follows: Potatoes, $16; oats, $16; wh $8 to $12. These increased gains were made without cost in ferti ing the land, as the alfalfa had been regularly cut for hay for years. In Colorado and Nebraska the yields of grain are sometin nearly doubled when immediately preceded by alfalfa.

As an instance of the effect of alfalfa on soils in the South, it m be mentioned that on the plantation of Mr. Ben De Gray, near Shre port, La., 23 bales of cotton, weighing 575 pounds each, were pr duced on 18 acres the season after an 11-year-old field of alfalfa h been plowed up. This soil had been in cotton for several years pr vious to the seeding of the alfalfa and had not given more than on half bale of cotton to the acre in any one season.

ADAPTABILITY OF ALFALFA TO ROTATIONS.

The value of a successful alfalfa field is so great that there i always the temptation to let it stand as long as it will produce pa ing crops. The difficulty of getting rid of a stand of alfalfa as we as the uncertainty of establishing the new stand and the high pri of the seed all work against the utilization of alfalfa in the ordinar rotations of the farm. There are many fields in the West more tha 25 years old which are still giving satisfactory crops of hay. With th gradual exhaustion of soil fertility, alfalfa is securing a place in th farm rotations in spite of the drawbacks to its use in this manner.

ALFALFA IN LONG ROTATIONS.

In the West an alfalfa field does not usually reach full maturity until the third year, and except in special regions it is seldom customary to plow down the alfalfa until it has been in at least five years. In the humid sections the rotation period is shorter, owing to the tendency of the alfalfa to run out in from three to five years.

Mr. Joseph E. Wing, of Mechanicsburg, Ohio, recommends the following rotation as being adapted to that section: Alfalfa, 4 years; corn, 1 year; beardless barley sown with alfalfa, 1 year. The cultivated corn crop affords opportunity to destroy any weeds which may have obtained a foothold in the alfalfa field.

ALFALFA IN SHORT ROTATIONS.

The expense incident to the establishment of an alfalfa field makes it usually of doubtful economy to turn under the alfalfa at the end of the first or second year, unless with the object of increasing the fertility of the land for some more profitable crop. In eastern Colorado the soils are lacking in the nitrates and phosphates, and it is now impracticable to grow more than two successive crops of sugar beets, cantaloupes, or potatoes. At the end of the second year the land is put into wheat to be followed by oats and alfalfa. The alfalfa makes a moderate growth the first season and at the end of the second season is turned under in preparation for another series of truck crops. The alfalfa is sometimes allowed to stand for more than two seasons.

In the Eastern States it is not usual for the alfalfa to stand more than a few years before it is overcome by weeds. The expense incident to establishing alfalfa is the principal drawback to its utilization in a short rotation such as is customary with red clover. Where the initial cost of establishing the alfalfa is not too great, the returns the first summer after early autumn seeding may be sufficient to justify turning the alfalfa under after securing the three cuttings which are possible during the first full growing season. The following tabulation indicates the approximate cost and returns per acre under this system:

Plowing	$2.00
Harrowing	1.00
Fertilizers	10.00
Lime	5.00
Rent	3.50
Seed, 25 pounds, @ $0.18	4.50
Seeding	.50
Harvesting, 3 tons, @ $2	6.00
Plowing under alfalfa	3.00
Total cost	35.50
hree tons of alfalfa, @ $15	45.00
ost, to be deducted	35.50
Profit	[illegible]

SHORT ROTATIONS ON SANDY SOILS OF THE NORFOLK

The soils of the Norfolk series are especially adapted to tru The residual effect of the fertilizers necessary for the truck c as potatoes, can be utilized by the alfalfa. In this connection, Galloway, Chief of the Bureau of Plant Industry, writes as

The following statements regarding the methods to be adopted i secure satisfactory crops of alfalfa are applicable to a type of so along the Atlantic coast from New England to South Carolina and Norfolk sand. The suggestions are particularly adapted to condition land and Delaware, where this type of soil exists. The Norfolk sa soil is thin and light, lacking in organic matter, but capable un management of producing good crops of several kinds.

Alfalfa on such soil is in its prime the first year after sowing and year usually begins to fail. Notwithstanding this fact we believe t profitable crop to grow and one worth going to considerable trouble Our preference is to keep the crop on the land only one year, or at crop years, and to this end we find that the most satisfactory method rotation planned for either three or four years, the number of years upon the vigor of the alfalfa the second season. The rotation we fo certain minor modifications, is given below:

First year: Early potatoes, alfalfa sown after potatoes are du 15 to 20.

Second year: Alfalfa.

Third year: Alfalfa.

Fourth year: Corn, crimson clover in corn at last cultivation, crim turned down early the next spring and land brought back to potatoe

For the potatoes we use a fertilizer containing approximately fro per cent of nitrogen, 8 to 10 per cent of phosphoric acid, and from 10 cent of potash. This is applied at the rate of from 1,200 to 1,500 p acre, half broadcast and half in the drills at the time of planting. W also put on about ten loads of well-rotted stable manure prior to plo additional fertilizer is used for the alfalfa.

As soon as the potatoes are dug the ground is thoroughly put in ground quicklime is drilled in at the rate of 1,000 pounds per acre. deavor to get the lime in about ten days or two weeks before the time ing the alfalfa. When all is ready for planting we apply from 2 pounds of soil per acre from a good alfalfa field. We then inoculate and sow same broadcast at the rate of 25 pounds per acre. After s seed the same is harrowed in with a spike-tooth harrow. We cut fro tons of alfalfa the following year. In the fall top-dress this with s nure, eight to ten loads to the acre, or about 500 pounds of complete with the constituents mentioned above. This fertilizer costs about $2 The second year's crop should yield about 1½ tons if conditions are f In about one-third of the cases, however, sorrel and other weeds will second season's crop. Coarse manure is spread on the alfalfa field i and winter and the next spring the ground is prepared and put in corn clover being sown at the last cultivation and then turned down the spring and the land brought back to potatoes again.

The rotation may be carried out by keeping the land in alfalfa year, and this is our preference. Following this practice we introdu the rotation running:

First year: Potatoes, alfalfa sown after potatoes.

Second year: Alfalfa.

Third year: Corn, wheat sown after corn.

Fourth year: Wheat, followed by crimson clover or cowpeas, the same being turned down for potatoes.

Our experience indicates that it does not pay to attempt to put down a permanent alfalfa field on this soil; hence, some short system of crop rotation must be adopted. The rotations, of course, will have to be planned to fit the needs of the individual in so far as labor, markets, and other things are concerned. We are running a number of other rotations, but the two foregoing will suffice as examples of standards which we believe are probably the most profitable, all things considered.

GETTING RID OF A STAND OF ALFALFA.

The methods adopted in eastern Colorado, where alfalfa is used to a great extent in short rotations, is to plow shallow in the fall and then plow deep the following spring. The plows are sometimes provided with a knife attachment to the land side to cut the roots near the outer edge of the next furrow. (See fig. 12.) A riding plow is preferable owing to its rigidity. The fall plowing exposes the crowns and a small portion of the root to the weather. The deep plowing the following spring so effectually buries the crowns that the limited amount of reserve food present in the severed portions does not enable them to reach the surface. The deep plowing also prevents the cultivator teeth from catching on the alfalfa roots when cultivating the succeeding crop. In some irrigated sections it is the practice to flood the field to kill the plants before plowing. In still other sections the stand is very heavily pastured, preferably with hogs. This so reduces the vitality of the plants that it is comparatively easy to get rid of them.

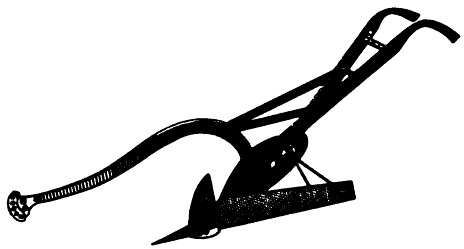

FIG. 12.—Plow with an attachment for cutting the alfalfa roots at the outer edge of the succeeding furrow.

SEED PRODUCTION OF ALFALFA.

The alfalfa seed producing sections of the United States are much more limited in extent than are the sections where the hay can be successfully raised. Alfalfa sets seed in paying quantities only when there is a comparative shortage in the moisture supply. In the irrigated sections it is the practice to withhold one irrigation when seed is desired. In the sections where alfalfa is raised without irrigation, a seed crop is usually secured in the dry years only.

Alfalfa requires a dry, hot season for the best development of the seed crop, and for this reason it is customary to save that crop for seed which will mature during the hottest and driest part of the summer. This is ordinarily the second crop, but south of central Kansas it may be the third crop, and in the northern sections may have to be the first crop, owing to the short growing season. In sections where the second crop would come only a little too late for the heat of midsummer, it is the practice to clip back the first crop when half grown. The alfalfa then comes on more evenly than had it not been cut back, and in addition blooms considerably earlier than had the full first crop been matured.

When allowed to make seed the alfalfa should be cut when from two-thirds to three-fourths of the pods have turned brown, as this will insure the greatest quantity of good seed. The methods of harvesting the seed vary widely in the different sections. A self-rake reaper, a mower with a dropping or bunching attachment, or a self-binder with the tying attachment removed is sometimes used. These leave the alfalfa in convenient forkfuls which reduce the amount of shattering in handling.

Alfalfa is thrashed from the field if possible, but it is often necessary to stack the crop before thrashing. An alfalfa huller built along the lines of a clover huller is usually most satisfactory, but few sections produce enough alfalfa seed to justify the use of these special hullers. Very satisfactory results can be secured with the ordinary grain thrasher by screwing down the concaves and providing a set of alfalfa sieves.

A thin stand of alfalfa is best for seed-producing purposes. The yields usually run from 2 to 5 bushels to the acre, but occasionally much higher yields are secured. Most of the alfalfa seed is produced in Utah, Idaho, Colorado, California, Arizona, Montana, Kansas, and Nebraska. The supply of seed raised in this country is far short of the demand, as is evidenced by the fact that over 6,000,000 pounds were imported during 1906.

ALFALFA IN CULTIVATED ROWS FOR SEED IN THE SEMIARID REGION.

Preliminary experiments indicate that the growing of alfalfa in cultivated rows for seed offers considerable promise of success in regions where the rainfall is sufficient for only one or two cuttings of alfalfa hay. Probably the most extensive area to which this method promises to be adapted is the Great Plains area immediately west of the one-hundredth meridian in Texas, Oklahoma, Kansas, Colorado, Nebraska, and South Dakota. This section is characterized each season by periods of relative drought, which are in accordance with the needs of alfalfa for seed production.

It has also been found that to give the best results the plants should be thin on the ground. Individual plants have been known to yield over an ounce of seed. The most promising method is to seed the alfalfa thinly in rows from 30 to 40 inches apart and cultivate the same as corn. It will usually be necessary to thin out the plants a they grow larger, since each plant requires isolation for the bes results in the production of seed.

ALFALFA VARIETIES.

Under most conditions, especially in the alfalfa districts, ordinary alfa, whether from American or European grown seed, gives quite satisfactory results as any of the special varieties. In certain tions of the country, however, special varieties of alfalfa have been und to be more valuable than the ordinary forms. Of these the urkestan, Arabian, and Peruvian varieties have been introduced rough the Office of Foreign Seed and Plant Introduction of the nited States Department of Agriculture.

TURKESTAN ALFALFA.

Turkestan alfalfa was introduced into the United States in 1898, d has since been tried in all parts of the country. It has been und to be superior to the ordinary alfalfa in only limited sections. is decidedly inferior in the humid sections east of the Mississippi ver, but has given somewhat better results than the ordinary alfalfa the semiarid portions of the Great Plains and in the Columbia sin. In addition to its drought resistance, it is also hardier than ny of the commercial strains.

HARDY ALFALFA.

There have appeared during the past years several strains of alfalfa ich are characterized by their hardiness and general ability to thstand conditions which are rather too severe for the best production of ordinary alfalfa. There is some variation in the characterics of these alfalfas, which may be grouped under this general head, t they agree in showing a considerable diversity in the color of the wers, which varies from yellow to blue, green, and various shades violet and purple. These colors are often clouded with a smoky e. The predominating color is the violet of the ordinary alfalfa. he most conspicuous examples of hardy alfalfa are the commercial nd lucern and the Grimm alfalfa of Minnesota.

The sand lucern has been grown for a number of years in this untry. It has recently been found to be adapted to the colder and ier sections of the country, where it is proving the equal of any the alfalfas under test. It seems particularly adapted to withstand cold winters of the Northern States, where ordinary alfalfa is y likely to winterkill. It is not always the heaviest yielder in ions where ordinary alfalfa succeeds, but its yields are always sfactory, and it is especially recommended for conditions where inary alfalfa does not succeed by reason of high altitudes, light nfall, or severe winters. Its chief drawback is its tendency to ge.

he Grimm alfalfa, which has been grown for many years in nesota with excellent success, was brought from Wertheim, Prove of Baden, Germany, in 1857, by a German farmer named Grimm.

It is claimed by some that this variety has attained increased hardiness since its introduction into Minnesota.

DRY-LAND ALFALFA.

Dry-land alfalfa is the name usually given to ordinary alfalfa seed produced for one or more generations in the semiarid sections without irrigation. It is proving somewhat superior to ordinary alfalfa under semiarid conditions, and as a drought-resistant alfalfa is about equal to Turkestan alfalfa and sand lucern.

ARABIAN ALFALFA.

Arabian alfalfa is proving of special value in the southwestern portion of the United States, where the winters are very mild. It is characterized by its large leaflets and the hairiness of the stems and leaves, quick recovery after cutting and very rapid growth during the growing season, and also by its ability to grow at cooler temperatures than ordinary alfalfa. On the other hand, it is extremely tender to actually freezing temperatures and generally winterkills in all except the Southern and Southwestern States. Its quick recovery after cutting and its longer growing season enable several more cuttings per season to be obtained than are possible for the ordinary alfalfa. Unfortunately seed of this variety is not yet on the market.

PERUVIAN ALFALFA.

Peruvian alfalfa is similar to Arabian alfalfa, and is likewise characterized by its long growing season and lack of hardiness. It grows taller than Arabian alfalfa, but the stems are more woody. The seed is not yet on the market in this country, as it is not grown in Peru or elsewhere in large commercial quantities.

ENEMIES OF ALFALFA.

WEEDS.

Over a considerable portion of the country weeds constitute the worst enemy of alfalfa. This is especially true in the humid sections and in those parts of the West and Southwest where the bulk of the rainfall comes during the comparatively mild winters. Witch-grass or couch-grass in New York and the New England States, crab-grass in the Eastern States south of New York, bluegrass in the bluegrass sections, and the " foxtail " or wild millets (*Chaetochloa* spp.) and crab-grass in the Central States are the worst enemies in the respective sections from the standpoint of the alfalfa plant.

In the irrigated sections of the West, especially in those sections characterized by rainfall during the comparatively mild winters, the growth of the wild barleys (*Hordeum* spp.) is a decided drawback to the successful production of alfalfa. They mature shortly before the first cutting of alfalfa, and the beards of the grass heads frequently first crop of hay, which is sometimes burned to destroy the ›d. These wild barleys are also known as foxtail grass, tail grass, and wall barley.

alfalfa is not usually a clean-cultivated crop the problem of struction is a serious one. Disking is usually the most remedy for weeds, as the alfalfa is generally benefited by the ı, while the weeds are greatly injured, owing to their different ems. In sections where the wild barleys are troublesome it mes thought necessary to burn the first crop of hay. Another is to cut the first ile the wild barley mmature and feed ure of alfalfa and ıy. The objection method is that it tes the cutting of fa when too young. growth of crab- sometimes burned rly spring.

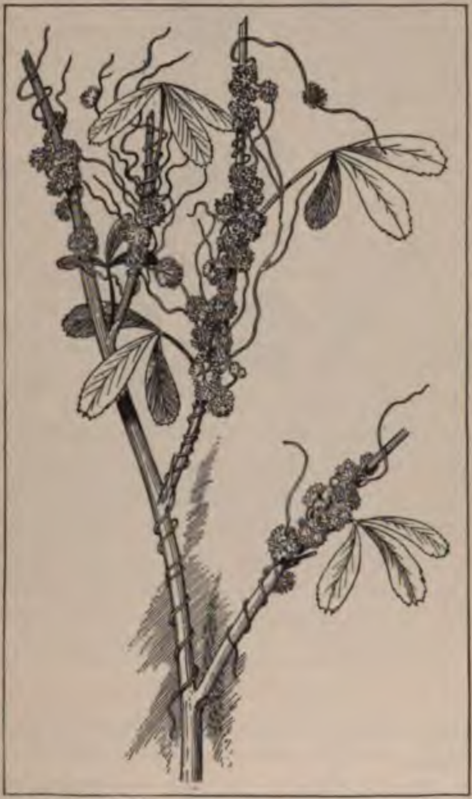

FIG. 13.—Mature dodder plant on an alfalfa stem.

r is one of the eeds so far as al- concerned. The nying illustration indicates the gen- earance of the ma- nt. The dodder erminate in the and the young soon attach them- the alfalfa seed- As soon as the e stem is firmly at- o the alfalfa plant connecting it with and withers away. rth the dodder lives entirely on the alfalfa (fig. 14). It is icult to eradicate when once established, and for this reason re should be taken to avoid introducing it with the alfalfa seeding time.[a] Grazing close with sheep has been recom- as being effective in holding dodder in check. If dodder in isolated spots through the field, it is advisable to cut the alfalfa plants very low and remove them. Destroying the dodder by burning with different inflammable materials has occ ally proved successful, but it is apt to be more expensive tha removal of the affected portions of the plants. If the stand of a is badly affected with der, the alfalfa shou plowed up before the der goes to seed an land kept in culti crops for two or years. The seed of d is illustrated in figur

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[a] ırmers' Bulletin 306, entitled "Dodder in Relation to Farm Seeds."

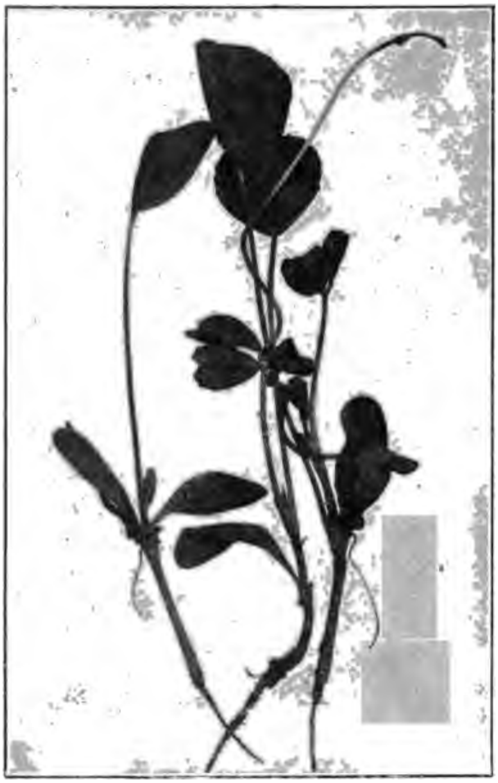

Fig. 14.—Young alfalfa plants attacked by dodder. As soon as the dodder thread fastens itself to the alfalfa the stalk attaching it to the ground withers and dies.

RODENTS.

The worst animal are gophers,[a] ground s rels, prairie dogs, mice. These are espe troublesome in the w half of the country, they injure the alfal eating the roots as w the foliage. The m of gophers are very a ing, as they interfere mowing. These pest less troublesome wher gating water is ava with which to drown out. The burrows, ever, cause the was much water when i ting. Poisoning and struction by traps and cats are the best means of holding the pe check.

INSECTS.

Grasshoppers are at present the worst insect enemies with alfalfa must contend. These are most troublesome in the ari tions of the West, where the alfalfa fields may be the only suc growth for miles, and the grasshoppers from large areas congr upon the relatively small fields of alfalfa. They are also espe destructive to the alfalfa in the semiarid sections where alfalfa be produced without irrigation. A flock of turkeys is often ef

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[a] See Biological Survey Circular No. 52, entitled "Directions for Des Pocket Gophers"; also Biological Survey Circular No. 32, "Directions Destruction of Prairie Dogs."

grasshoppers in check, as is also a sheet-iron device
" hopperdozer," which is run over a field and catches the
rs in an open oil-filled pan.[a]

very effective means of destroying grasshoppers is to disk
ı late winter. This exposes the half-developed young to
ɔring freezes and to the attacks of birds. This operation
ome extent effective against the alfalfa webworm (*Loxo-
ıixtalis*).

eetles also prove troublesome at times when they appear
able numbers. The general practice is to cut the alfalfa
ıearance of any such pests, when they will be forced to
ıigrate. The alfalfa and clover chalcis fly (*Brucophagus*
found also in Europe and Siberia, is proving destructive
fa seed crop wherever it is grown.[b]

PLANT DISEASES.

e two general classes of diseases which affect the alfalfa
ely, those which affect the roots and those which attack
ıd leaves. Of the former, root-rot (*Ozonium omnivorum*)
t important. This disease is practically identical with
-rot and prevents the successful production of alfalfa in
e portions of eastern and southern Texas. It spreads in
ircles throughout the field, causing an almost complete
of the stand as the disease progresses. There is no prac-
y, and land so affected must be kept out of alfalfa or cot-
eral years. Another disease which attacks the alfalfa roots
rotium " disease, which appears as black excrescences about
wheat grains. There is no practical remedy for this dis-
han to throw the land out of alfalfa for a number of years.
seases which attack the leaves and stems, the leaf-spot dis-
lopezia medicaginis) is the most common. This appears
black spots on the mature leaves. Leaf-rust (*Uromyces*
ɔduces small reddish spots on the leaves. Powdery mildew
trifolii) and downy mildew (*Peronospora trifolii*) form
ches of considerable size on the leaves. Another form of
sease (*Macrosporium sarcinaeforme*) is sometimes destruc-
appears in the form of well-defined circular spots which
rous small black dots scattered over their surfaces. The
ve remedy is to cut the plants when any of these diseases
rove destructive. This process invigorates the plant, and
spores by which the disease is spread are destroyed. The

ıau of Entomology Circular No. 84, entitled "The Grasshopper
Alfalfa Culture."

ıu of Entomology Circular No. 69, entitled " Some Insects Affecting
on of Red Clover Seed."

anthracnose disease (*Colletotrichum trifolii*) attacks the stems and forms purple patches which gradually increase in size. This is destructive locally in the East. No effective remedy has been discovered for this disease.

SPECIAL INSTRUCTIONS FOR GROWING ALFALFA, ARRANGED BY SECTIONS OF THE UNITED STATES.

NEW YORK AND THE NEW ENGLAND STATES.

Alfalfa is grown with some difficulty on the soils in New York and the New England States, with the exception of the limestone areas. Outside of the limestone regions liming is always necessary. Even in the limestone areas it is often advisable to apply lime. At least a ton of lime to an acre is usually required, and more than this may be necessary on the heavier soils. Well-rotted barnyard manure is the most satisfactory fertilizer, but a complete commercial fertilizer may be used in the absence of the manure.

When the alfalfa is once started under favorable soil conditions, weeds, including bluegrass, are likely to prove the most dangerous enemy. For this reason it is best to precede the alfalfa for at least one or two seasons with some clean-culture crop. The best method is to manure heavily in late winter or in early spring; then plow and lime, and at seeding time harrow frequently to prevent weed growth and to produce the necessary fine tilth and firm seed bed.

Inoculation with nitrogen-fixing bacteria is essential unless the soil is known to be naturally supplied with these germs. The seed should be sown alone at the rate of 20 to 30 pounds per acre. It may be drilled or sown broadcast and covered lightly with a smoothing harrow. Sowing with a nurse crop in the early spring is practiced in some sections, but better results are usually obtained by waiting until early summer and seeding the alfalfa alone.

Good results may also be obtained by seeding the latter part of July on land which has been repeatedly harrowed for several weeks. This method is recommended in case weeds are thought to be troublesome. Alfalfa is more likely to winterkill under this last method, but this danger may be less than that of the weeds on a weedy soil if sown in the spring.

A half bushel of oats to the acre may be seeded with the alfalfa in late summer. These will make considerable growth before being killed by the cold weather. The dead clumps of stems will catch the snow, and thus afford protection to the alfalfa plants.

In most parts of New York and the New England States alfalfa growing is still in the experimental stage. The experiments which may well be performed according to the directions given under the heading "Need of experimenting at first" are (1) application of at different rates; (2) comparison of manure and commercial ilizers; (3) seeding at different times.

r. F. E. Dawley, of Fayetteville, N. Y., in a recent letter gives following brief suggestions based upon his experience and obser- ions:

eeds are usually a serious pest, and some previous crop to rid the soil of e in a measure is advisable. Hoed crops, such as corn, potatoes, and cab- , are very satisfactory. Near canning factories it is often practicable to a crop of peas before the alfalfa is seeded. This calls for July seeding he alfalfa. The ground is simply disked after the vines have been removed. eeding alfalfa the three most serious difficulties are lack of proper inocula- of the soil, which is largely overcome by the use of soil from successful lfa fields; acidity of the soil, which is corrected by the use of lime and d ashes; and improper drainage. From 25 to 30 pounds of seed to the acre generally used to insure a full stand. A medium application of complete lizer is usually made at seeding time. Most successful alfalfa growers top- s their alfalfa fields about once in three years, spreading from 8 to 15 s of well-rotted stable manure with a manure spreader.

MIDDLE ATLANTIC AND SOUTHERN STATES.

n the Middle Atlantic and Southern States the limestone soils best adapted for the production of alfalfa. Even these soils n require liming for the best success. In the nonlimestone regions soils require heavier liming to overcome the natural acidity of soil. A deep, fertile, well-drained, well-limed soil is required.

ell-rotted barnyard manure is the most satisfactory fertilizer. en-manure crops are also efficient in building up the humus con- of the soil. If neither of these can be used, commercial fertilizers be applied. A good formula is muriate of potash, 75 pounds; rock, 250 pounds; and nitrate of soda, 50 pounds, to the acre.

noculation with nitrogen-fixing bacteria is almost always essen- to success. The seed should be sown without a nurse crop, and at rate of from 20 to 30 pounds to the acre.

pring seeding is generally unsatisfactory, as the plants are very ly to be choked out by the weeds of midsummer. Late fall seed- is open to the same objection and to the additional drawback of g likely to cause winterkilling. The ideal time of seeding is in late summer after the greatest danger of weeds is past. Repeated rowings for six weeks preceding the sowing time will destroy successive crops of germinating weeds and put the land into an l, well-settled, finely pulverized condition for the alfalfa seed.

he date of the seeding will vary as one passes from north to h. In the latitude of Washington, D. C., August 15 is usually ; in North Carolina, September 15 is recommended; and in the eme South the seeding may be delayed until the middle of Octo- In the South the danger of fall drought sometimes makes it ssary to postpone the seeding until February.

In most parts of this section alfalfa growing is still in an experimental stage, and it is usually necessary for each farmer to do some preliminary experimenting before seeding a large field. The points which need to be definitely determined in any given section are the best kinds and quantity of fertilizers to use and the amount of lime necessary to bring the soil into proper condition for alfalfa.

The following extracts are taken from a letter written by Mr. B. H. Strong, of West Point, Miss., indicating his methods of producing alfalfa:

> We get the best results in growing alfalfa where we follow cotton, as the cultivation of cotton leaves the land in perfect condition. In preparing cotton land for alfalfa we simply break out the center of the cotton row, plowing up the stalks with a "buster" plow, then run a disk harrow across the rows at a right angle, which leaves the land smooth. We then harrow with an iron-tooth harrow, sow the seed, and harrow again. I have used from 22½ to 30 pounds of seed per acre, sowed with the wheelbarrow seeder, and find I get the best results where I use 30 pounds.

OHIO, MICHIGAN, INDIANA, ILLINOIS, IOWA, MISSOURI, EASTERN KANSAS, AND EASTERN NEBRASKA.

Throughout this section late summer seeding is giving the best results, although spring and fall seeding are usually successful in the western part of this section. Liming and inoculation are advisable, except in Kansas and Nebraska. The seed should be sown alone at the rate of about 20 pounds per acre. If sown in the spring the soil cannot usually be put into proper condition before the middle of May.

If the weeds prove troublesome it may be necessary to harrow the ground repeatedly until midsummer to destroy the successive crops of weeds as they germinate. The alfalfa seed can then be sown and the plants still attain a considerable size before winter. Alfalfa is more likely to winterkill under this last method of seeding, but this danger is usually less than that from the weeds when sown in the spring.

A nurse crop of beardless barley or oats is sometimes successfully used by experienced alfalfa growers, but the practice is not recommended, as it is apt to injure the stand of alfalfa. The plants should be at least 6 inches high if they go into the winter, in order that the snow may be caught for the protection of the plants.

The following extracts are from statements made by Mr. Joseph E. Wing, of Mechanicsburg, Ohio:

> Alfalfa is easily established in this section, provided certain rules and requirements are met. First, one must sow on dry, well-drained ground. The water table should be down at least 30 inches, and it is much better if it can be lowered 60 inches below the surface. Away from the limestone it is a safe rule to thoroughly lime the land a year before seeding. The safest form of lime is the ground, unburned limestone. This may be applied in any amount up to 5 or 10 tons per acre without injury to the land and with relatively permanent

ct. The soil itself must be made rich. Stable manure is best; about 300 nds of 16 per cent acid phosphate to the acre is also very beneficial. Inocu-on is often very helpful. Inoculation with soil from a good field of alfalfa sually the most practicable method. It is also a good plan to seed a small ount of alfalfa on the prospective alfalfa field the year previous, as this ally insures inoculation. The ground when plowed must be harrowed fre-ntly and given every opportunity to become well settled. If spring sown, a se crop may usually be used. This had best be beardless spring barley, hough oats may be substituted. About a bushel of either to the acre should sown. It is generally necessary to cut these early for hay. The alfalfa uld not be cut till buds have set on the stems near the base and are starting make the new growth.

f late seeding is practiced the land should be plowed late in the spring and weeds kept down by harrowing until seeding time. It is also possible to ove an early maturing crop in early July in time for early August seeding.

RTH CENTRAL STATES (MONTANA, NORTH DAKOTA, SOUTH DAKOTA, MINNESOTA, AND WISCONSIN).

n the North Central States it is necessary to seed alfalfa in the ing or early summer, owing to the inability of the fall-seeded nts to make sufficient growth to prevent their being winterkilled. month or six weeks should usually be allowed for freshly plowed d to settle. If spring seeding is practiced, fall plowing is usually essary. Corn-stubble land may, however, be disked in the spring l settled firmly enough by two or three harrowings. In the less d eastern portion of this section early summer seeding often gives most satisfactory results. In the semiarid portions of this section e must be taken to conserve the soil moisture by proper methods of ture previous to seeding.

Inoculation with nitrogen-fixing bacteria is usually necessary and uld be used unless the soil is known to be well supplied with the ms. The seed should be sown at the rate of about 20 pounds to acre, generally without a nurse crop, although in Wisconsin a se crop with spring-seeded alfalfa has frequently been successfully d. In all cases the alfalfa should be allowed to go into the winter h at least a month's growth, as this will hold the snow and tend to tect the crops from injury during the winter.

IRRIGATED SECTIONS.

lfalfa is especially adapted to the irrigated sections of the United tes. The dry climate is apparently essential to the best growth he plants and the water supply can usually be controlled so as to pplied when most needed. The seeding usually takes place in the ng, and quite often some small-grain crop is seeded with the lfa. The alfalfa is so thoroughly at home that it succeeds in e of the nurse crop rather than by reason of it.

the extreme South and Southwest it is often the practice to seed fa in the fall with small grain. In most cases the land receives a thorough irrigation shortly before seeding. The crust is broken when the seeding takes place and the moisture is usually sufficient to enable the plants to make a satisfactory start. It is sometimes the practice to irrigate the ground immediately after seeding and then irrigate a second time just as the seedlings are trying to break through the crust. The plants are then able to get through the crust before it has a chance to form a second time. This method, however, is not usually to be recommended.

It is generally the best practice to irrigate alfalfa a few days before cutting and then give a second irrigation when the crop is about half grown, which is commonly about fifteen days after cutting. The advantage of irrigating before rather than immediately after cutting, as is often the practice, is that there is not the delay in starting the new growth. This delay may be injurious, as several days are usually required to get the hay off the ground, and in the mean time there is almost no growth on the part of the alfalfa.

Experiments performed by the Utah Agricultural Experiment Station in cooperation with the United States Department of Agriculture indicate that a relatively small amount of water properly applied is sufficient for satisfactory crops of alfalfa. The following table indicates a partial summary of the results:

Results of experiments in irrigating alfalfa in Utah.

Inches of water applied.	Number of irrigations.	Yield per acre. In tons.
17.058	3	3.125
17.38	4	3.468
24.97	4	5.017
25.002	2	1.55
61.465	12	6.243

Methods of Irrigation.

The check system of irrigation as practiced principally in California calls for a heavy initial expense, but when once the squares or contour checks are constructed the irrigations can be made at a minimum of expense for labor and water. The flooding system from ditches is in common use throughout most of the alfalfa sections of the West, and while somewhat wasteful of water it does not demand the heavy initial outlay for careful leveling of the ground, as is the case with the system of checks just mentioned. The furrow system is much less used for alfalfa than the two former methods, but is especially adapted to soils subject to alkali.[a]

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[a] See Farmers' Bulletins Nos. 158, entitled "How to Build Small Irrigation Ditches," and 263, "Practical Information for Beginners in Irrigation;" also Office of Experiment Stations Bulletin No. 145, entitled "Preparing Land for Irrigation and Methods of Applying Water."

SEMIARID REGIONS.

The principal factor in the successful production of alfalfa in the miarid sections is the conservation of soil moisture before the alfalfa seeded. The proper preparation of the ground for planting usually lls for special treatment of the soil for at least a year preceding e time of sowing in order that the rainfall of the entire year may stored up in the ground and may be available for the young alfalfa ants.

Fall seeding is not usually advisable, owing to the danger of ought and the small growth which the plants are able to make fore winter. For this reason spring seeding is usually practiced, en though the danger of weeds in summer is considerable.

The seed should be sown broadcast or drilled in at the rate of 8 to pounds of good seed per acre. A more nearly even stand can be ured by dividing the seed and sowing one-half each way across field. If sown broadcast, a harrow should be used to cover the d 1½ to 2 inches deep. If the soil is sandy and likely to blow before e plants can make sufficient growth to cover the ground, a half shel of oats per acre may be seeded with the alfalfa.

Unless weeds prove very troublesome the first clipping should not ke place until the plants are well toward full bloom or until the sal shoots are well started for the second crop. Recent experiments ow that larger plants are produced when they are left uncut during e first season. If an experimental tract of several plots is established, as suggested under the heading "Need of experimenting at st," the points which need determining are different methods of evious preparation of the ground; time, rate, and manner of seedg; and whether the alfalfa should be clipped the first season.

EASTERN OREGON AND EASTERN WASHINGTON.

Alfalfa is thoroughly established in the irrigated portions of this tion and its culture is gradually being extended in the semiarid irrigated sections, although much lighter yields are obtained than ere the crop is grown under irrigation. In the absence of more ught-resistant plants, however, alfalfa takes front rank as a leguous forage plant. On dry soils it is slow in becoming established, t not until the third year are the best results to be looked for.

he ground should, if possible, be summer fallowed the previous son to destroy the weeds and conserve the moisture for the germinat of the seed. Intertilled crops, such as corn and potatoes, instead of summer fallow, may precede alfalfa. Spring seeding is generally ticed, as the fall rains usually come too late to permit fall seeding. impossible to precede alfalfa with summer fallow or intertilled s, a small-grain crop may be used, in which case the stubble should lowed under as early in the autumn as possible and left unharrowed until early spring, when it should be thoroughly worked a packed before seeding. The seed should be sown broadcast or dril at the rate of 10 to 12 pounds per acre and covered about 1½ ind deep. The alfalfa should be clipped high when the basal or cro buds begin to grow into stalks even though the weeds are not troub some. There is some evidence to show that under very dry conditio the plants should not be clipped the first season.

Under favorable conditions one cutting of hay may sometimes procured toward the end of the first season. Alfalfa should not pastured until the third season, and even then but sparingly if t stand is to be maintained. Disking early the second season is usuall advisable to break the crust and stimulate the plants. Alfalfa wi stand a great deal of harrowing without injury, and in this way t weeds are held in check and the moisture is conserved. In most this section the raising of alfalfa without irrigation is still in t experimental stage. The experimental plot described under the hea ing "Need of experimenting at first" should include variations the preparation of the soil; time, manner, and rate of seeding; and t treatment of the plants the first two years.

Mr. Max Hinrichs, of Pullman, Wash., an extensive grower alfalfa without irrigation, writes in part as follows:

> As a result of past experience I now seed only on land that has raised a c vated crop, as corn or potatoes, the previous year. I sow not to exceed 5 p of choice seed per acre. I find that it is essential to have a thin, even under the dry-land conditions here. I first disk the land thoroughly in spring, about the first week in April; drill 35 pounds of oats or barley; harrow, seed the alfalfa broadcast, and harrow again. I prefer to cut the a little green, but usually get a good crop of grain. The next spring I give alfalfa a good harrowing, or if the land is very hard a light disking is best repeat this cultivating every spring, disking deeper each succeeding yea

SOME ALFALFA DON'TS.

Don't fail to provide for ample inoculation; soil from an old alf field is best.

Don't sow poor or weedy seed.

Don't sow on a weedy soil.

Don't sow on any but a sweet, well-limed soil.

Don't sow on poorly drained soil.

Don't sow on any but a finely prepared, well-settled seed bed.

Don't pasture the first or second year.

Don't lose the leaves; they constitute the best part of the hay.

Don't seed a large acreage to begin with. Experiment on a s area first.

Don't give up. Many prominent alfalfa growers finally succ only after many failures.

O

SAN FRANCISCO

Issued December 5, 1908.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 340.

DECLARATION OF GOVERNORS FOR CONSERVATION OF NATURAL RESOURCES.

WASHINGTON:
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1908.

SAN FRANCISCO

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Forest Service,
Washington, D. C., October 28, 1908.

Sir: Believing that the Declaration of Governors adopted at the recent conference on conservation of our natural resources is worthy of the widest circulation among the people, and that it will do more than anything else that could be published to arouse a popular interest in this very important subject, I respectfully recommend its issuance as a Farmers' Bulletin.

Respectfully,

Gifford Pinchot,
Forester.

Hon. James Wilson,
Secretary of Agriculture.

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DECLARATION OF GOVERNORS FOR CONSERVATION OF NATURAL RESOURCES.

INTRODUCTION.

The Declaration of Governors contained in this bulletin was pted by the conference of governors of the States and Terri- ies called by the President to consider the conservation of our ural resources, and which met at the White House May 13, 14, d 15, 1908. Besides the governors there were invited to the ference the members of the Cabinet, the justices of the Supreme urt, the members of both Houses of Congress, representatives of great national organizations, the Inland Waterways Commis- n, and, as special guests, Hon. William Jennings Bryan, Mr. James Hill, Mr. Andrew Carnegie, and Mr. John Mitchell. The late ex- esident Grover Cleveland was also invited as a special guest, but ness prevented him from attending. At the request of the Presi- nt each governor brought with him to the conference three citi- ns from his State or Territory to act as assistants or advisers.

The object of the conference was stated by the President in his ter of invitation to the governors, in which he said:

> t seems to me time for the country to take account of its natural resources, and nquire how long they are likely to last. We are prosperous now; we should not et that it will be just as important to our descendants to be prosperous in their e.

Papers which discussed the present state of our various natural ources were read by experts and specialists in each respective s, and these were followed by an open discussion among the gov- ors of the points brought out.

The conference then appointed a committee to draft a declara- n, consisting of the following: Governor Newton C. Blanchard, Louisiana; Governor John Franklin Fort, of New Jersey; Gov- or J. O. Davidson, of Wisconsin; Governor John C. Cutler, of h; and Governor Martin F. Ansel, of South Carolina.

This committee prepared and submitted the declaration which ows, and it was unanimously adopted by the conference of gov- ors as embodying their conclusions on the question of conserva- n.

DECLARATION.

We, the governors of the States and Territories of the United America, in conference assembled, do hereby declare the convict the great prosperity of our country rests upon the abundant res the land chosen by our forefathers for their homes, and where t the foundation of this great nation.

We look upon these resources as a heritage to be made use of i lishing and promoting the comfort, prosperity, and happines American people, but not to be wasted, deteriorated, or n destroyed.

We agree that our country's future is involved in this; that t natural resources supply the material basis upon which our civ must continue to depend, and upon which the perpetuity of the nati rests.

We agree, in the light of the facts brought to our knowledge a information received from sources which we can not doubt, th material basis is threatened with exhaustion. Even as each suc generation from the birth of the nation has performed its part in ing the progress and development of the Republic, so do we in this tion recognize it as a high duty to perform our part; and this large degree lies in the adoption of measures for the conservatio natural wealth of the country.

We declare our firm conviction that this conservation of our resources is a subject of transcendent importance, which should unremittingly the attention of the nation, the States, and the pe earnest cooperation. These natural resources include the land on w live and which yields our food; the living waters which fertilize th supply power, and form great avenues of commerce; the forests whic the materials for our homes, prevent erosion of the soil, and conse navigation and other uses of the streams; and the minerals whic the basis of our industrial life, and supply us with heat, light, and

We agree that the land should be so used that erosion and so shall cease; and that there should be reclamation of arid and s regions by means of irrigation, and of swamp and overflowed reg means of drainage; that the waters should be so conserved and us promote navigation, to enable the arid regions to be reclaimed b gation, and to develop power in the interests of the people; that th which regulate our rivers, support our industries, and promote the and productiveness of the soil should be preserved and perpetuat the minerals found so abundantly beneath the surface should be as to prolong their utility; that the beauty, healthfulness, and bility of our country should be preserved and increased; that so national wealth exist for the benefit of the people, and that monopoly should not be tolerated.

We commend the wise forethought of the President in sounding the ote of warning as to the waste and exhaustion of the natural resources f the country, and signify our high appreciation of his action in calling is conference to consider the same and to seek remedies therefor through operation of the Nation and the States.

We agree that this cooperation should find expression in suitable action y the Congress within the limits of and coextensive with the national risdiction of the subject, and, complementary thereto, by the legisla- res of the several States within the limits of and coextensive with eir jurisdiction.

We declare the conviction that in the use of the national resources our dependent States are interdependent and bound together by ties of utual benefits, responsibilities, and duties.

We agree in the wisdom of future conferences between the President, embers of Congress, and the governors of States on the conservation of r natural resources with a view of continued cooperation and action on e lines suggested; and to this end we advise that from time to time, in his judgment may seem wise, the President call the governors of ates and Members of Congress and others into conference.

We agree that further action is advisable to ascertain the present con- ion of our natural resources and to promote the conservation of the same; d to that end we recommend the appointment by each State of a com- ssion on the conservation of natural resources, to cooperate with each er and with any similar commission of the Federal Government.

We urge the continuation and extension of forest policies adapted to ure the husbanding and renewal of our diminishing timber supply, the vention of soil erosion, the protection of headwaters, and the main- ance of the purity and navigability of our streams. We recognize t the private ownership of forest lands entails responsibilities in the erests of all the people, and we favor the enactment of laws looking the protection and replacement of privately owned forests.

We recognize in our waters a most valuable asset of the people of the ited States, and we recommend the enactment of laws looking to the servation of water resources for irrigation, water supply, power, and igation, to the end that navigable and source streams may be brought der complete control and fully utilized for every purpose. We espe- lly urge on the Federal Congress the immediate adoption of a wise, tive, and thorough waterway policy, providing for the prompt improve- nt of our streams and the conservation of their watersheds required for e uses of commerce and the protection of the interests of our people.

We recommend the enactment of laws looking to the prevention of ste in the mining and extraction of coal, oil, gas, and other minerals h a view to their wise conservation for the use of the people, and to the tection of human life in the mines.

Let us conserve the foundations of our prosperity.

O

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FARMERS' BULLETIN 341.

THE BASKET WILLOW.

BY

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Forest Assistant, Forest Service.

WITH A SUMMARY BY C. D. MELL, ASSISTANT DENDROLOGIST, FOREST SERVICE.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Forest Service,
Washington, D. C., November 17, 1908.

Sir: I have the honor to transmit herewith a manuscript entitled "The Basket Willow," by William F. Hubbard, Forest Assistant, Forest Service, and to recommend its publication as a Farmers' Bulletin. This paper is a condensation and revision of Bulletin 46 of the Forest Service.

Very respectfully,
Gifford Pinchot,
Forester.

Hon. James Wilson,
Secretary of Agriculture.

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THE BASKET WILLOW.

INTRODUCTION.

cultivation of the basket willow began very early. Among the
t Romans the shoots were used for the manufacture of bee-
and baskets, for garden and vineyard fences, and for binding
ines, and the wood, covered with hide and bossed with brass,
ade into shields, for which purpose its elasticity and lightness
arly fitted it. During the middle ages willows were commonly
or basket ware, and in France, and later in Germany, the basket
rs' guilds were of considerable importance. During the seven-
and eighteenth centuries, however, the industry languished.
he present time France, Italy, the islands of Sicily and Madeira,
m, Holland, Germany, Austria, and Russia are all large growers
ow, and have a good export trade of willow rods and basket ware.
these thickly peopled countries, which abound in cheap labor,
growing and basket making have followed the development
er manufactures to a very marked degree. In the United
the conditions are altogether different from those on the con-
of Europe. Here raw material is cheap in comparison with
st of labor, and nearly every branch of manufacture tends
centrate in large establishments with a great number of labor-
devices. Such an industrial condition has relegated basket
g to a very small position in the general world of manufacture.
comparatively small part of our population is made up of highly
killed laborers; the great bulk of the people is scattered in the
ltural districts, doing more or less independent hand labor.
been observed in all countries that willow growing gives an
monly high margin of profit. A large demand for willow is
upplied by import, and as American-grown rods are of good
when proper care is taken in their culture, there is no reason
he further development of the industry should not be possible,
American farmers can be convinced of its practicability.
ough the last census shows a great falling off since 1899, as
he import of both rods and basket ware, the manufacture of
furniture, which is lost in the total figures, shows a most prom-
ondition when separately considered. Of late years willow
re has sprung into fashion, and to-day no minor industry is
rosperous than that devoted to its supply. The wages are

good, and the manufacturers demand a steady supply of sup low. This is now almost entirely received from France a which will give the entire trade to the American if he can quality. In basket ware proper the decline seems to hav bed rock. Experience has proved that no stock is equal when durable baskets are demanded. The high-class b made a place for itself in the market even under presen stances, and the entire decline in the trade has been in the l basket, which competes with the foreign willow produc American-made wooden basket. To put a low-priced bask market with raw willow at its present price the wages mu lower than the normal standard in America. For this r trade is almost entirely in the hands of immigrant basket who know no other trade and who are seldom or never reenf native workmen.

The remedy lies in a reduction in the cost of the raw The cheaper the willow (when good in quality) the better t which can be paid to produce a low-priced basket, and a lo basket of good quality will find an almost unlimited market. point the entire trade agrees.

Thus the problem has but one solution. A good grade o must be produced at a low cost. To do this, better and more s methods must be introduced. At present the willow is grow rudest manner possible, and several inferior varieties are The following pages will show how the yield per acre may be in and the quality of stock bettered. The price will then fall, b a corresponding gain to the grower in the lessened cost of pro On this depends the future success of basket making in A An incentive to improvement should be the fact that ever present conditions the American willow tends to displace the in the home market.

DISTRIBUTION AND CHARACTERISTICS OF THE W

DISTRIBUTION.

Willows are adapted to a wide range of soils and climati tions, and are therefore among the most widely distributed and shrubs. The genus Salix, to which these plants belong, a large number of species, ranging from large trees to a sm plant. From 160 to 170 species are known, inhabiting all from the low grounds and river banks of temperate climates an countries to the arid Alpine slopes of mountains and to th regions of both hemispheres.[a] They occur in America fr

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[a] There are at least 92 varieties, hybrids, and crosses of the basket willow en in the dealers' catalogues.

Arctic Circle to the West Indies and the mountains of Chile. In the Old World they range from northern Europe and Asia to Madagascar and South Africa, and to the islands of Java and Sumatra.

True to the characteristics of the genus, the basket willow also has a wide distribution over varying climatic conditions. In Europe *Salix viminalis, amygdalina, purpurea,* etc., are successfully grown from Russia, Sweden, and Norway far down into Italy and the Mediterranean islands. In America it is difficult to decide positively just how far the commercial range of the European basket willow coincides with the boundaries within which it is at present grown. How far willow growing can be extended in this country may be found only by actual experience; yet there is every reason to believe that suitable places for willow growing exist throughout the entire United States. There is continual record of small imports of willow from the West Indian islands; and it is quite certain that northern willows suffer quite as much from insect pests as those on the southern boundary of the present willow-growing section. For these reasons it would seem that the South has a good future for this industry if favorable positions are sought for the holts. On the Pacific coast also the high transportation rates which must be paid for the foreign or eastern article should give willow growing a chance to become an economic industry. A start has already been made in California.

CHARACTERISTICS.

In a genus with such a wide range it is but natural that the wood should answer many needs. Both in Europe and to a lesser degree in America the wood is used for many purposes. In this report, however, only the basket willow will be considered.

Although the willow is one of the most widespread and accommodating of plants, and shows such an endless variety of strains, the varieties used in basket making will by no means flourish commercially on all kinds of soil. It is a mistaken idea, however, that it will thrive only on marshy land, though it is true that a fresh soil is needed. That the willow is nevertheless characteristically found in wet places when growing wild is due less to its demands than to its adaptability. It has a poor height growth, and being also intolerant of shade, finds its only chance for life in its capacity for soil adaptation. It is not at all sensitive to moisture, and hence is forced to grow on river banks and lowlands. This is further necessitated by the fact that its seeds can not sprout save on soft, open soil which is free of weeds, and lose their powers of germination in a few days. Such seeds, when left to nature's conditions, find their most favorable bed on the soft alluvial deposits of river banks.

When grown as an article of commerce, the willow is remove all natural competition, and therefore should be put in a p suited for its development. Both European and American exp have shown that rods grown on moist, rich, well-drained bottc are more flexible, tougher, and less branchy than those gro undrained marsh land. This does not mean that valuable should be given over to the willow. The most exacting of tree less sensitive to soil conditions than any farm crop, and willows on soil which produces even a very poor quality of grass. B fact remains that the swamp is not the favorite home of the willow, and, if a high grade of osier rod is wanted, land perma saturated with water should be avoided. Ground which is ofte flowed grows willow of a high quality, but it must be well d Long-continued inundation is fatal to all species (fig. 1). Nor its excessive intolerance of shade be forgotten. Weeds and growth of any kind prevent its luxuriant development.

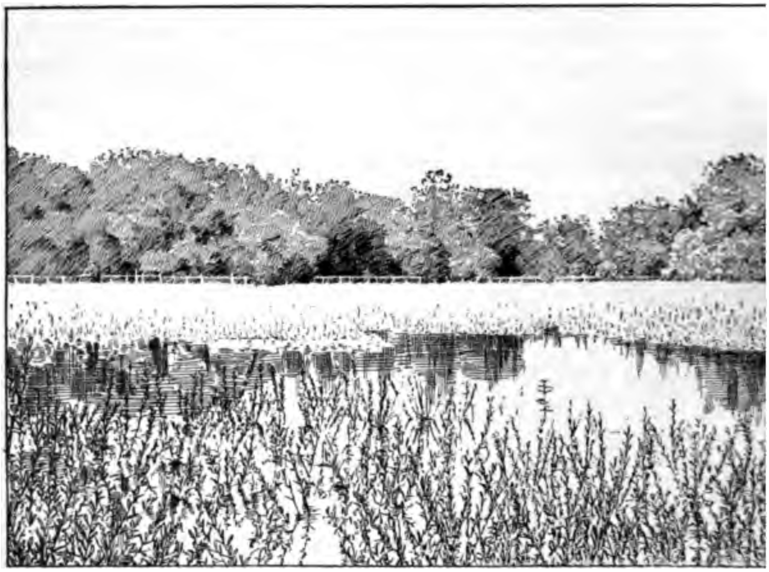


FIG. 1.—Purple or Welsh willow (*Salix purpurea*), part of which has been killed by stand New York, July, 1902.

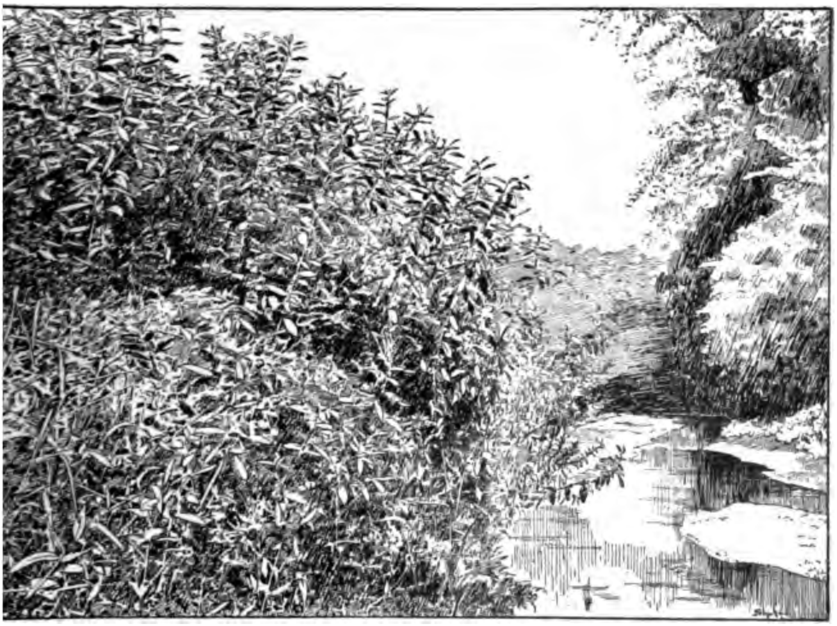
THE PRESENT CULTURE OF WILLOWS IN AMERIC

Although introduced by German immigrants in the period b 1840 and 1850, willow growing in America occurs only in res localities throughout a relatively small portion of the country cause the growers are thus isolated into small groups with littl connection, and because these growers are very seldom in touc e basket makers, there has been little chance for general improve-ent. It is true that in western New York basket maker and grower e in close communication, but there the trade demands only the heapest grade of the steamed willow—a condition which, far from eing an advantage to the grower, has been his greatest handicap.

Because of these conditions, and, further, because the system of ulture, like American agriculture in general, has lacked intensive-ess, little or no advance has been made on the method introduced ixty years or more ago.

POSITION OF THE HOLT, OR WILLOW PLANTATION.

Although the idea is common that willows grow only on swampy round, it takes but little experience to explode this fallacy (fig. 1).



i. 2.—Almond or American green willow (*Salix amygdalina*) on well-drained bottomland; rods 7 to 8 feet high. Maryland, September, 1902.

ence all serious attempts at willow culture are made on well-drained il, even though it be of poor quality. In many places willows are own on ordinary corn land, but generally they are planted in low-ing fields subject to occasional inundation (figs. 2, 3, 4, and 5), or the swales and low places of grain fields, subject to the overflow or ainage of sudden rain storms. When planted on high ground the nd chosen is deep and heavy, but when the holt (or willow bed) is ibject to inundation the land may be of poorer quality.

PRELIMINARY CULTIVATION.

In most parts of the country the ground is prepared for w exactly as it would be for corn or wheat. The work is generally in the preceding autumn, occasionally in the spring. Often whe willows are to be planted on waste bottomland subject to inund the wild growth is simply cut down and burned on the field and th lows are planted either with preliminary cultivation or in the ra

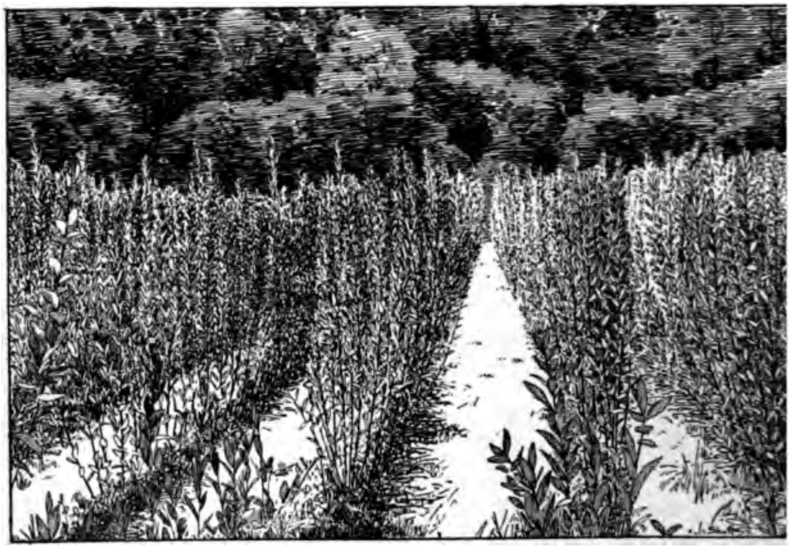


FIG. 3.—Purple or Welsh willow (*Salix purpurea*) planted 3 feet by 1 foot. Maryland, Septem

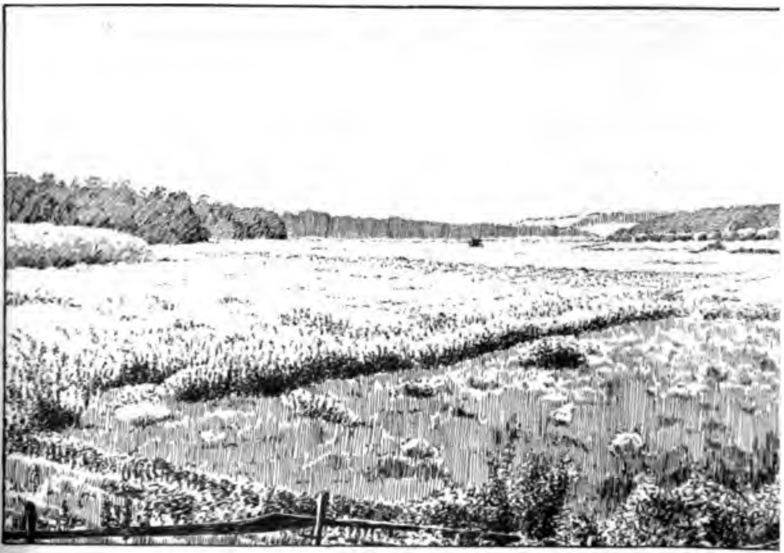
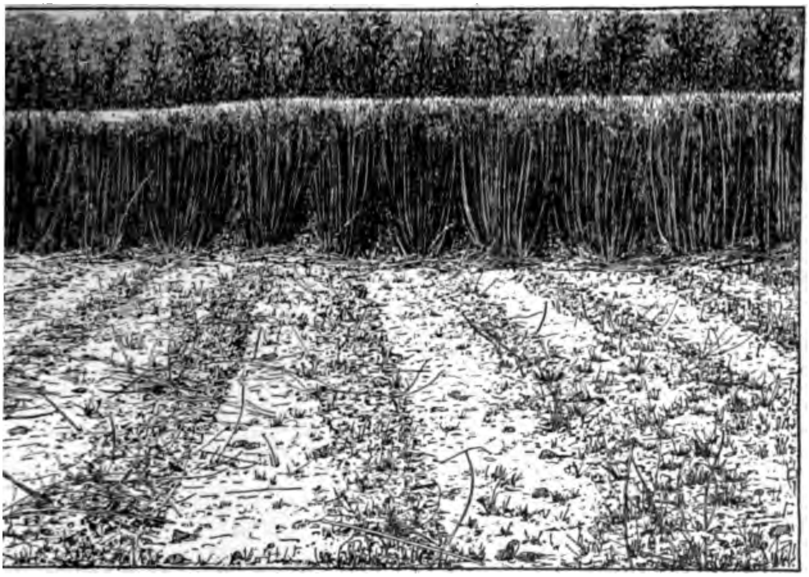


FIG. 4.—Typical willow bottomland. Maryland.

PLANTING.

most without exception throughout the country willows are :ed from 9 inches to a foot apart, in rows 2½ feet to a yard distant one another, or from about 14,000 to 23,000 per acre. Here and : occasional growers plant in closer order—even 18 by 8 inches[a]—hey are the decided exception. This method of wide planting is wed for several reasons. It is undoubtedly cheaper to plant fewer ngs, and the cost of cultivation is much reduced, as a plow may m through the wide rows. It is also a generally held opinion the more shoots from a stool (or stump) the greater the yield. lly, the practice is continued because those who introduced the stry planted in this manner.



IG. 5.—Willows on drained land; cut and subsequently inundated. Maryland, March, 1903.

he sets (or cuttings) are cut from one-year shoots into sections ut 10 inches to a foot in length and are generally planted with ut an inch and a half out of the ground.

WEEDING AND CULTIVATION.

he care of a holt depends so much on the character of the ground ; two systems must be separately discussed.

Villows on meadow or corn land.—In the first year the rows are l about three times and later run through occasionally with a light v or cultivator. In subsequent years only the plow is used, ral times in the season.

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[a] 'or results from close spacing see Forest Service Circular 148, "Practical Results asket Willow Culture."

Willows on bottomland.—In the first year these are sometimes cultivated once, but as a general thing they are only thoroughly grassed with a sickle. This is done twice in the first season and subsequently but once. As the land is inundated every spring, a heavy coat of mud is deposited, therefore no fertilizing and but little cultivation is necessary (fig. 5). This advantage, however, is partially offset by the stimulated growth of weeds, which are very difficult to keep suppressed.

CUTTING.

Unless the holt has been very well tended, the first-year rods may be of little value. They are, nevertheless, cut. As a general rule, however, they are not cut very close, and the projecting head of the set is allowed to stay (fig. 6). This makes the stool branchy and knotty from the first—a very serious fault. In the second year the rods of a carefully cultivated holt should have at least half the value of a full crop and from the second or third year the holt should yield at least twelve good, paying crops. Only a few growers realize the value of an occasional rest. As a rule the holt is cut annually until exhausted. Where steam peeling is practiced, the willows are generally cut as soon as the leaves have fallen in November, so that they may be stripped in the winter. In districts where sap peeling is common the rods are allowed to stand on the stump until March

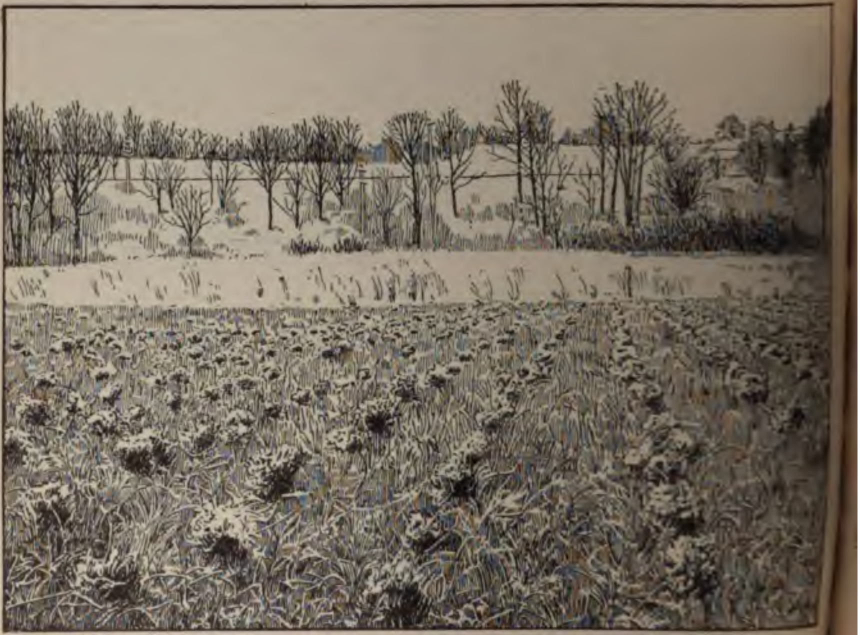
FIG. 6.—Effect of undrained land. Maryland, March, 1903.

when they are cut and immediately drafted (fig. 7), tied into bundles, and put into the pit (fig. 8).

By letting the willows stand all winter and cutting them early in the spring, any trouble in housing the rods is saved. In some districts, however, it is customary to wait until the sap begins to run. This is most objectionable, as the stools bleed and lose vitality.

The cutting is generally done with a knife somewhat similar to that shown in figure 9. In almost every district the value of low cutting is fully appreciated, but the work is seldom carefully done in this respect, mainly because of the added expense.

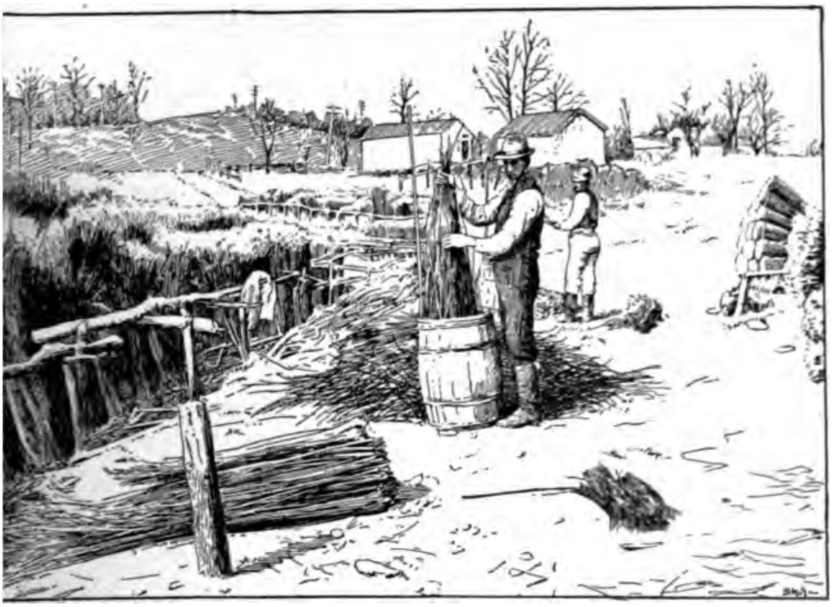

FIG. 7.—Drafting (sorting) willows.

DRAFTING AND PEELING.

After cutting, the rods are immediately sorted into four sizes and undled. This is called drafting, and is most conveniently done in the manner shown in figure 7. An armful of rods is put into a barrel nd sorted according to size with a measuring stick. All rods below go into the smallest size, those between A and B into the next, those etween B and C into the next, and all over C into the largest size. bout 40 pounds are put into a bundle, which is firmly bound and aken immediately to the pit (fig. 8). This pit is a series of shallow onds of water, not over 4 inches deep, in which the bundles are tood. Racks are arranged at regular intervals to keep the bundles pright and secure, but they should not be too closely packed. After he willows have stood in the water for two or three weeks the rods become almost entirely covered with tender, green foliage, while the submerged end is a mass of rootlets. In this condition they are ready for the peeling, which should begin at once. Peeling is done by a man and two strippers, the latter being either boys or women. The brake used for removing the bark (fig. 10, Nos. 4, 5, 6, and 7) is inserted in a beam at a convenient height and the rod passed through it, first in one direction and then in the reverse (fig. 11). This loosens the bark; the strippers then peel it off, either with the fingers or with a dogwood or metallic hand brake (fig. 10, Nos. 1, 2, and 3) and carry the rods to the drying racks (fig. 12), where they are laid in the sun to dry, care being taken to keep the rods in the four sizes arranged in the drafting. After they are sufficiently dry they are tightly bundled by a machine (fig. 13), and in this form shipped to the manufacturer. The machine here illustrated is not in common use, but from its simplicity and efficiency should be more generally introduced. It can be made by hand on the place with the aid of a blacksmith. The main feature is the binding strap, which is so crossed on the axle that by turning the latter the pressure is exerted on the rods not only from *the top,* but also from the sides and underneath. A cog and ratchet

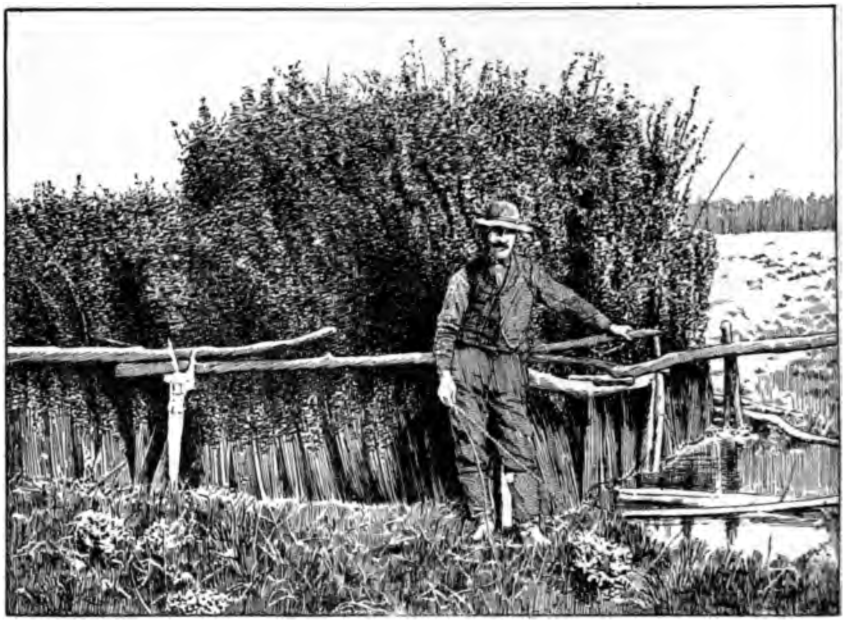

FIG. 8.—Willows in the pit, sprouted and ready for peeling.

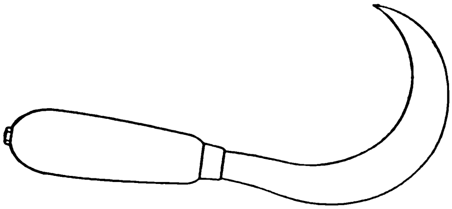

FIG. 9.—Knife for cutting rods.

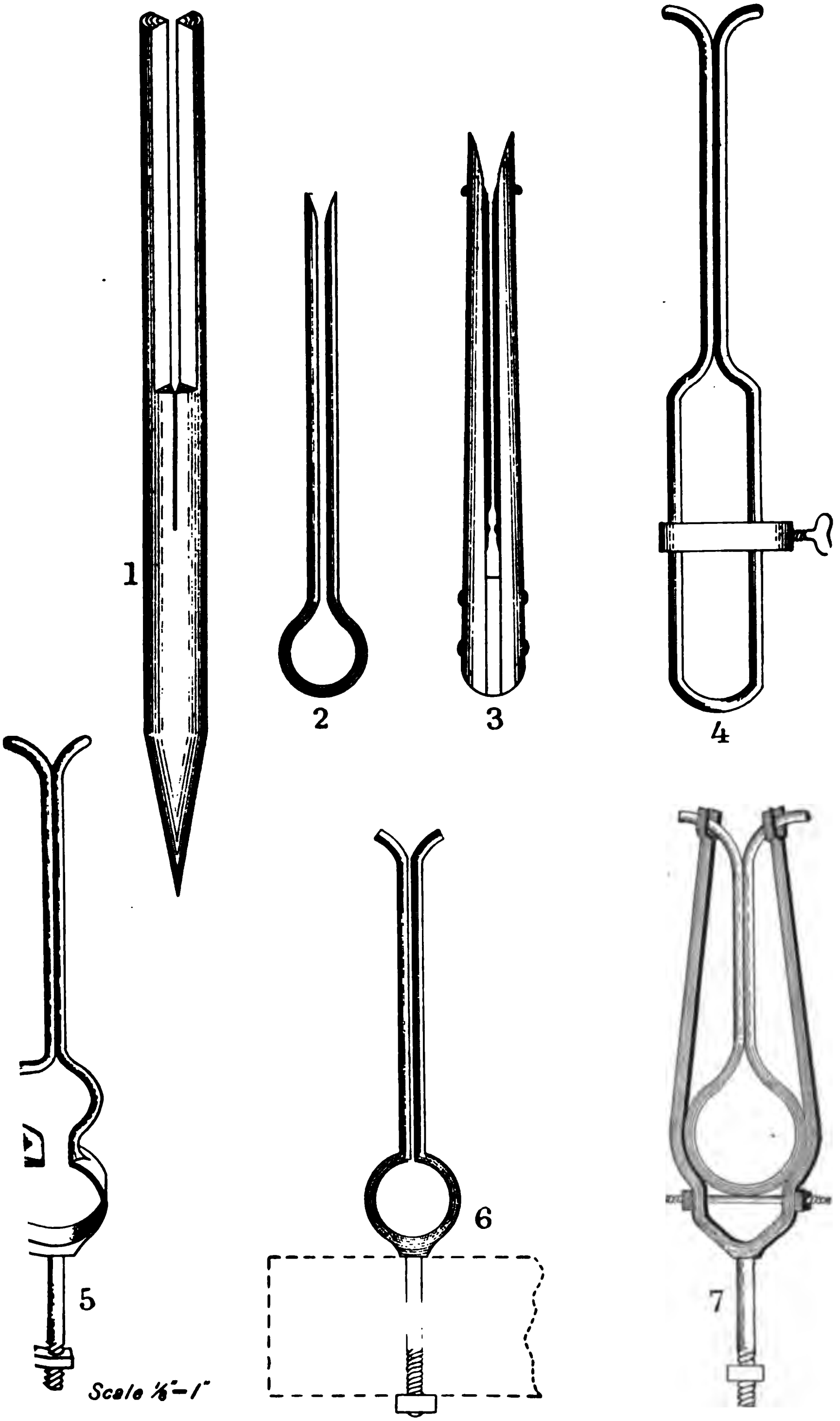

Fig. 10.- Seven types of brake.

attachment on the axle holds the tension while the bundle is being tied; the necessary cord is held in a reel under the machine.

It does not pay to peel the smallest size of rods with the rest, so they are generally put out to families to peel at a given rate per pound, women and children doing the work. The grower makes little or no profit on these rods, but the basket-maker's demand for a certain amount of small stuff makes it necessary to have such stock on hand.

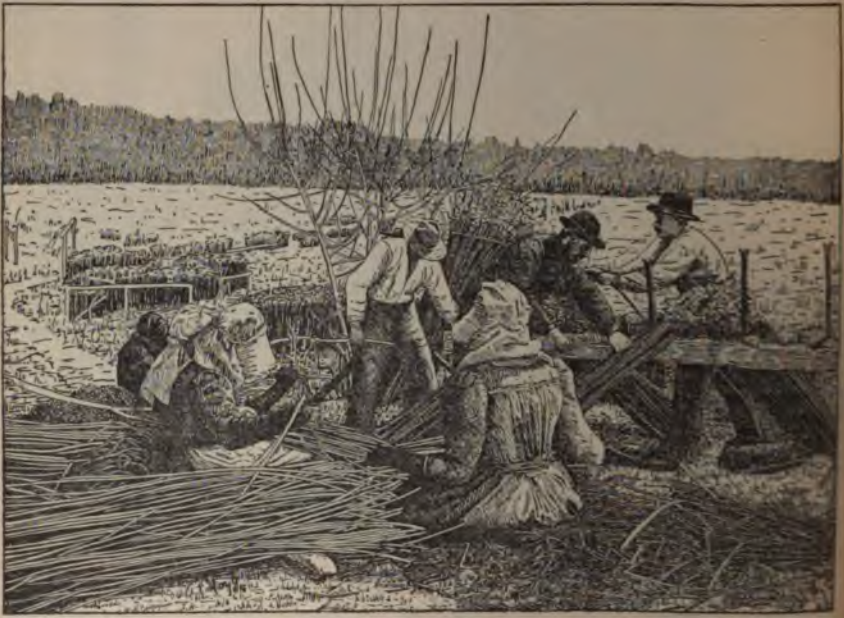

FIG. 11.—Peeling willows in the sap.

SUGGESTED IMPROVEMENTS IN CULTURE.

The following suggestions concerning willow culture in America have been prepared after a careful study on the ground of actual conditions both here and in Europe. While the introduction of any new system in a particular locality calls for a consideration of questions of labor, market transportation, etc., all of which can not be taken into account in a general discussion, there is room for many improvements on present methods, and the intelligent application by the individual grower of the information here given should enable him in most cases decidedly to increase his profits.

CHOICE OF LAND AND PRELIMINARY CULTIVATION.

Any extra expense incurred in the preliminary cultivation of the soil will be repaid in the increased yield. The land should be plowed d harrowed exactly as for any field crop, and should be fertilized th lime or wood ashes if calcareous constituents are lacking. Even lds subject to inundation should be well cultivated before planting. If the holt is to be planted on land which is never flooded, the soil ould be deep and moist, but not necessarily rich. If the land is sub-ct to inundation in the spring, it should be thoroughly drained. Not ly are the rods brittle and of poor quality on swampy soil, but the inter frost forces the stools out of the ground, making large heads ove the surface and neutralizing the effect of good cutting (fig. 6).

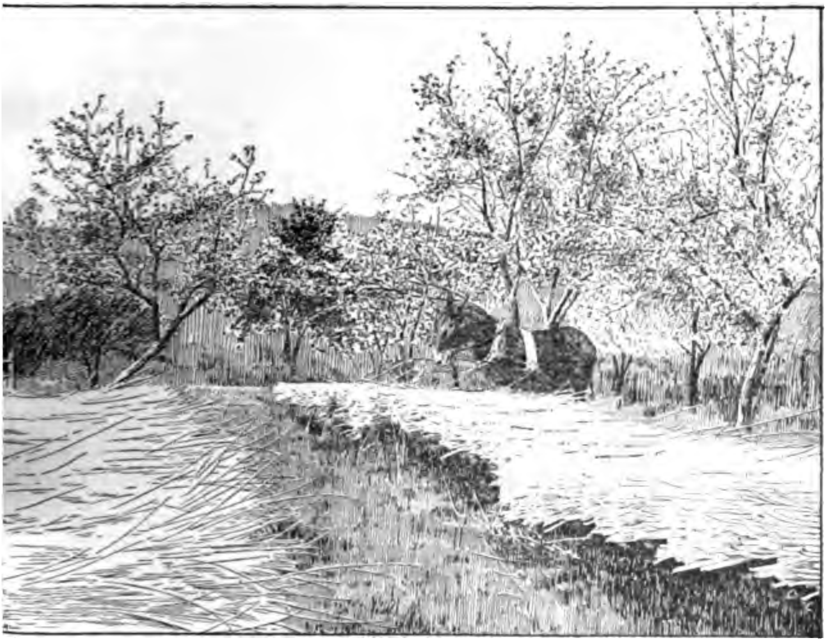

FIG. 12. Drying the peeled rods on the racks.

There is no doubt that land subject to inundation is the best for illow growing. If it can be perfectly drained and the flooding regu-ted, ideal conditions are present for the production of high-grade ock. The flooding does away with any need for fertilizer, and the yer of deposit keeps the stools well covered (fig. 5), while if the ater stands long enough, the larvæ of insects are likely to be killed. ll these advantages counteract the additional danger from weeds, hich can be kept under if attacked early enough in the season. In suitable location flooding can be inexpensively provided for by the nstruction of a weir dam. This would easily pay for itself in the cility with which the water could be regulated. Figure 14 shows a od location for willow growing on inundated land.

By planting from 34,000 to 81,000 sets per acre, or at distances from 20 by 9 inches to 16 by 6 inches, both a much heavier yield and longer, more even-sized, and better rods are obtained—straighter, less branchy, and less tapering.[a] (Fig. 15.) The main objections to close planting are the increased initial cost, the greater amount of cultivation necessary, and the more rapid exhaustion of the holt. But the average yield from a holt planted 3 feet by 1 foot after the second year is 4 tons green per acre for about twelve years, while that from an acre planted 20 by 9 inches should not be less than 6 tons green for ten years. This gives the close-planted holt an excess yield of 12 tons over the one planted 3 feet by 1 foot, to say nothing of the extra yield in the first and second years. In Tables I and II the expenditure and return under both systems of planting are given in detail. (See pp. 28, 30.)

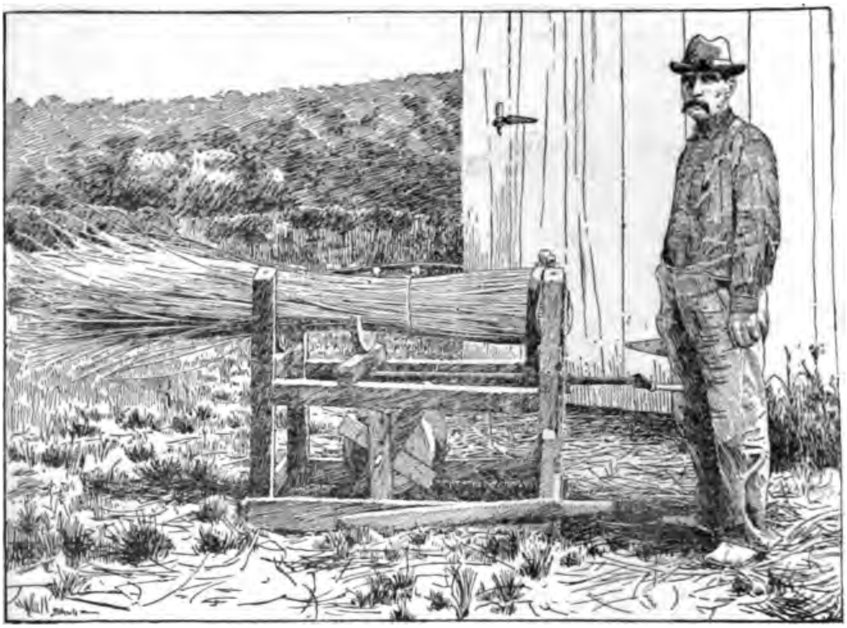

FIG. 13.—Machine for bundling willows for market.

These estimates, however, take no account either of the improved quality of the entire crop or of interest on the larger profits secured. With these reckoned in, a much larger balance in favor of close planting would be obtained.

Of course the conditions which determine the application of different methods of willow growing are purely local, and the price of labor and the market for the stock must fix the method of culture.

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[a] See Forest Service Circular 148.

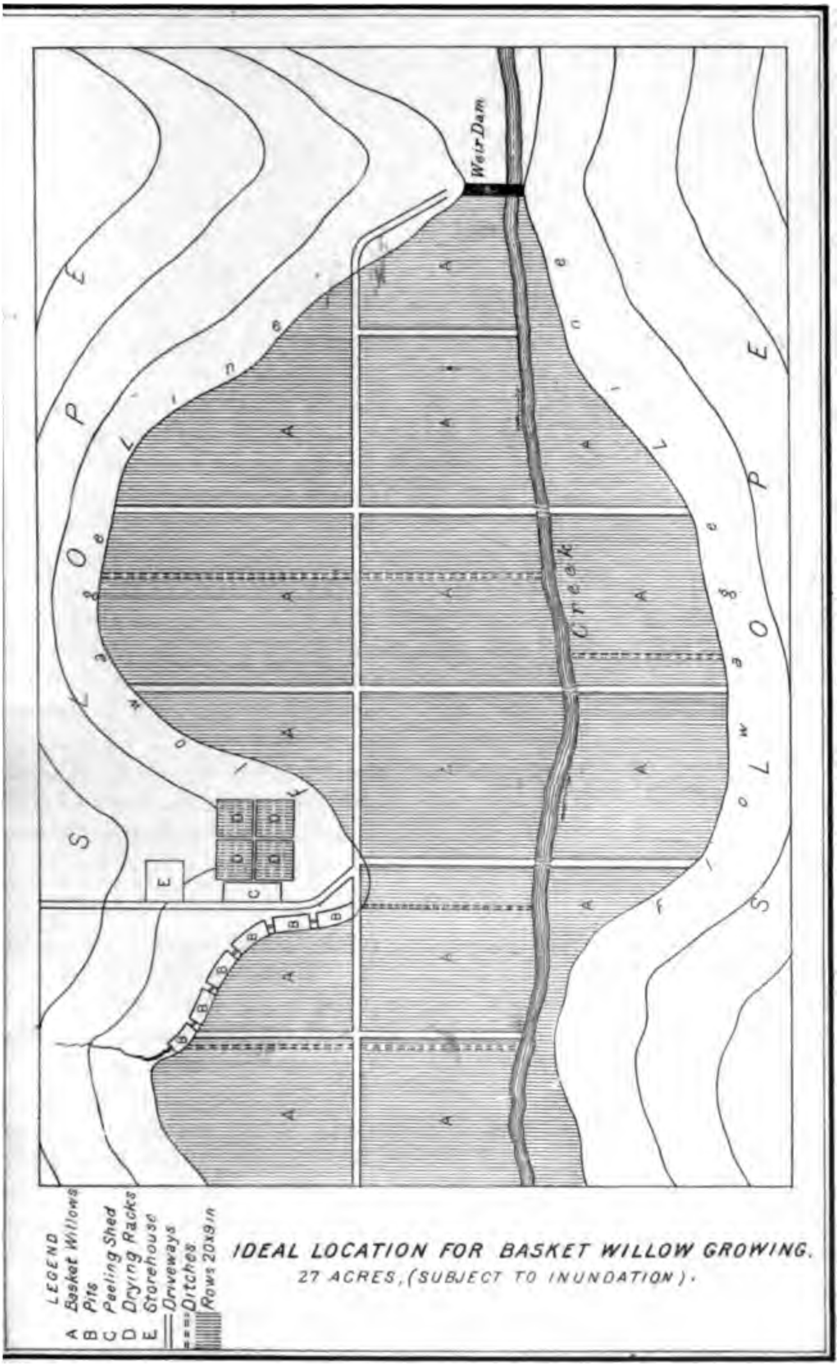

FIG. 14.—Ideal location for basket willow growing.

but if labor can be obtained and the market is thoroughly known, a willow holt will pay as much as any field crop, and possibly more. While in many instances it would not be advisable to change the present method of cultivation, there are places where close planting and careful cultivation would undoubtedly pay handsome returns. For American conditions, 20 by 9 inches, giving about 34,000 plants per acre, would probably be the best distance. Care should be taken that the sets are 12 inches long and planted with the buds pointing upward, and that they are pushed into the ground perpendicularly to within 1 inch of the top.

WEEDING AND CULTIVATION.

When willows are close planted it is absolutely essential that weeds and grass, under all circumstances their arch foes, should be kept out during the early life of the holt. Afterwards, when the stools have become vigorous, they are able from their close rank to shade out other plants if the first cultivation in the spring has given the weeds a setback. But in the first year the cultivation should be so thorough that the weeds may get no chance to develop. In normal years three or four hoeings should suffice for this. Two hoeings should be given the second year. After that time one hoeing should be sufficient. The first cultivation should take place very early in the spring, before the stools have begun to sprout, and the soil should be heaped up over the plants. If the ground has been inundated after cutting, the stools will be sufficiently covered, and the first cultivation may be deferred until the weeds begin to start.

Two thorough hoeings under normal circumstances will be found to cost little more than ordinary grassings or other methods of cultivation in vogue, and it is but little more trouble to hoe an acre set with 34,000 plants than one with 14,000.

FERTILIZING.

On ordinary soil willows should be fertilized every four or five years, beginning with the fifth or sixth. This makes two treatments during the normal life of a close-planted holt. Any ordinary field manure may be used. If the land is flooded in the spring, no other fertilizing is necessary.

INSECTS.

In combating the danger from insects, a first requisite is united action by all the growers of one neighborhood. A few uncared-for holts will completely neutralize all the efforts of careful growers. Against the ravages of such insects as the cottonwood leaf-beetle or caterpillars, spraying with poison is generally efficacious if commenced early enough in the season.

One of the most terrible willow scourges is the willow-shoot sawfly. For this a good remedy is to cut the willows entirely off immediately after the fly has made its appearance, and to be effective this must be done throughout the whole region, even at the sacrifice of a year's crop.

For information in regard to insects affecting the basket willow and methods for their control, application should be made to the Bureau of Entomology of this Department, and it will greatly facilitate correspondence if specimens of the insects accompany letters of complaint or inquiry.

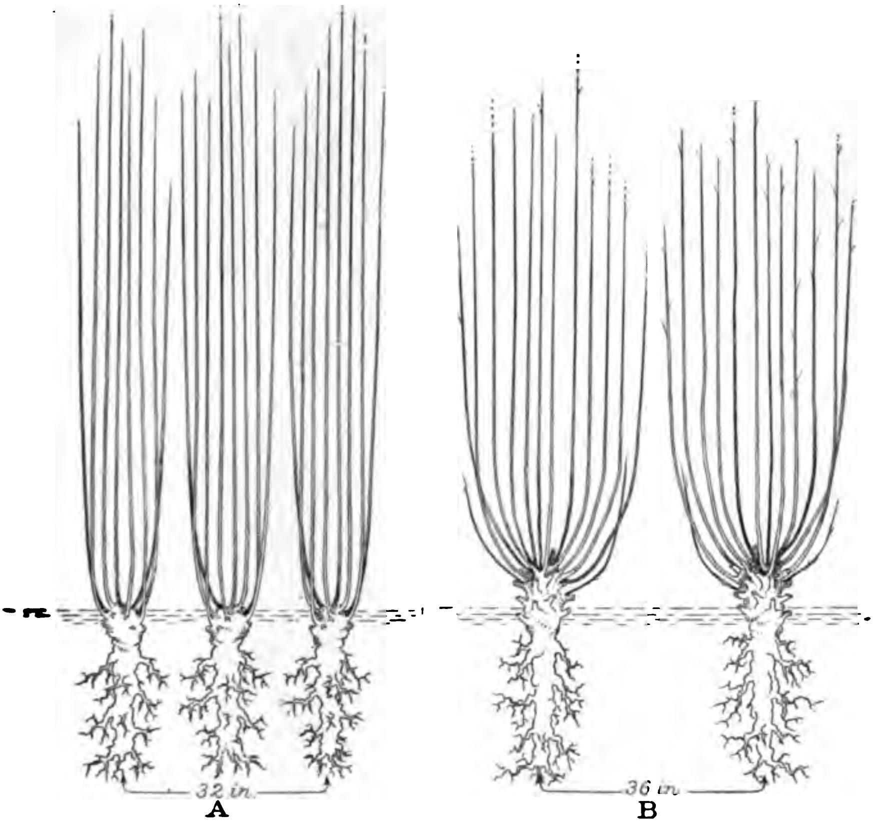
32 in.
36 in.
A
B

FIG. 15.—Comparison of close planting and good cutting with wide planting and careless cutting.

CUTTING.

When the rods are to be steamed, they may be cut any time during the period of rest, but when they are to be sap peeled it saves storage to let them stand on the stools until the spring. Care, however, should be taken to cut them before the sap begins to move.

The necessity for close cutting can not be too much emphasized. The rods should be taken off as close as possible to the stool.[a] Figure 15 shows the difference between good and bad cutting. A illustrates the growth of the rods from a low-cut, compact stool, and B that from a high-branching one.[b]

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[a] For the results from later experiments in cutting see Forest Service Circular 148.

[b] Figure 15 is taken from actual examples.

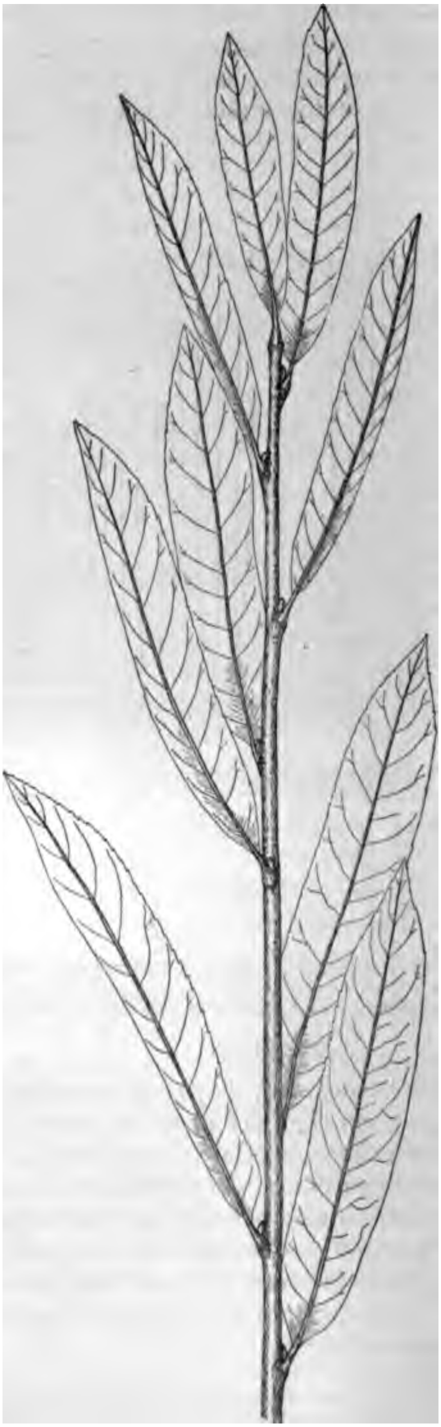

Fig. 16.—Welsh or purple willow (⅓ natural size).

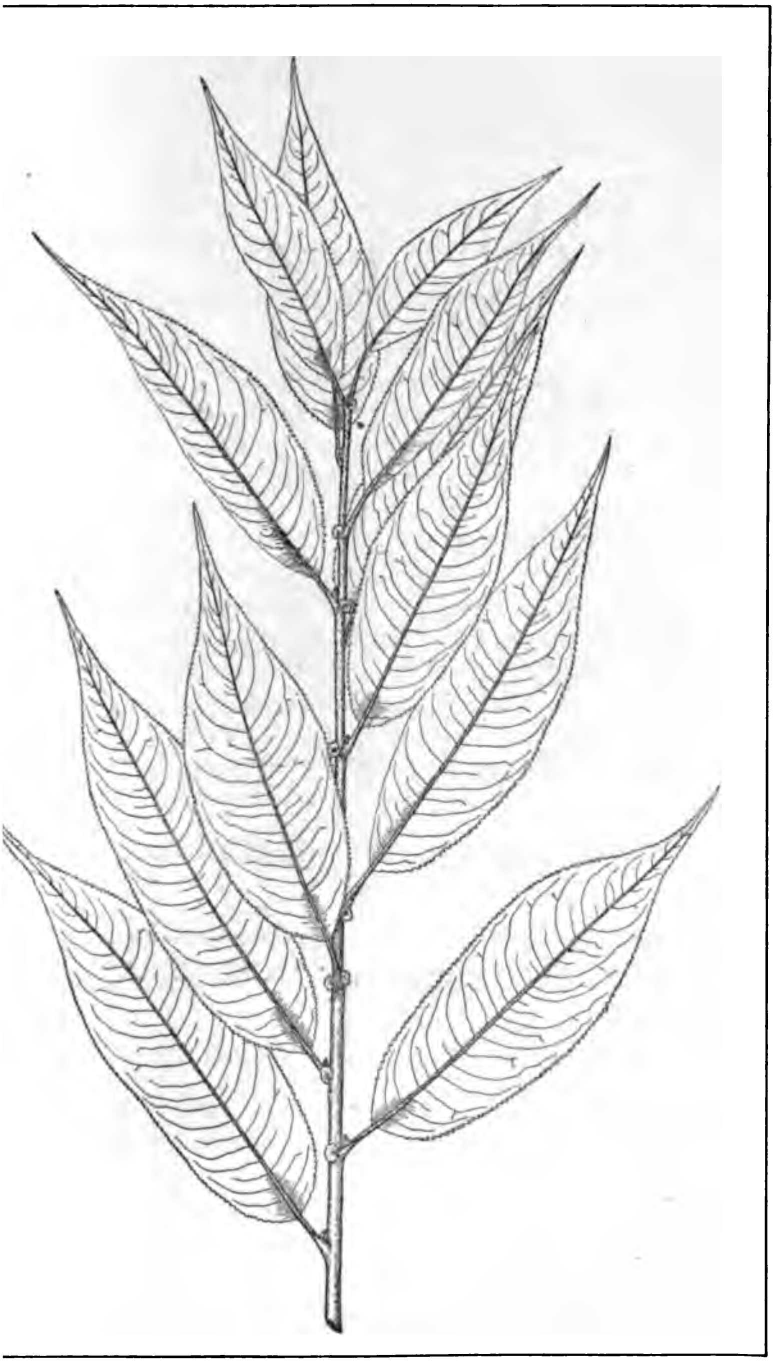

Fig. 17.—Lemley or Caspian willow (⅔ natural size).

TABLE I.—*Willow culture on upland.*

	A.—Steam-peeled rods as grown in New York.			B.—Steam-peeled rods to be grown 20 by 9 inches apart.			C.—Sap-peele to be grown inches apart.	
	First year.	Second year.	Third to fourteenth years.	First year.	Second year.	Third to twelfth years.	First year.	Second year.
Annual expenses per acre.								
Preparation of land	$10.00			$10.00			$10.00	
Sets	[a] 14.00			[a] 35.00			[b] 105.00	
Planting	4.50			12.00			12.00	
Plowings, at $1 each	2.00	$2.00	$2.00					
Hoeings, at $4 each	8.00	8.00		16.00	$12.00	$8.00	16.00	$8.00
Spraying	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Cutting:								
Salable rods, at $5 per ton	5.00	10.00	20.00	7.50	20.00	30.00	10.00	20.00
Left-over rods	1.00	1.00	1.50	1.00	1.00	1.50	1.00	1.00
Drafting, at $3 per ton							6.00	12.00
Peeling, at $10 per ton							20.00	40.00
Total	48.50	25.00	27.50	85.50	37.00	43.50	184.00	85.00
Annual returns per acre.								
Willow:								
Green, at $15 per ton	15.00	30.00	60.00	22.50	60.00	90.00	75.00	150.00
White, at 5 cents per pound								
Gross gain		5.00	32.50		23.00	46.50		65.00
Gross loss	33.50			63.00			109.00	
Amount of net loss of previous year, with interest at 5 per cent		35.18	31.69		66.15	45.30		114.45
Net gain			.81			1.20		
Net loss	33.50	30.18		63.00	43.15		109.00	45.25

[a] Welsh willow, at $1 per M.
[b] American green, Lemley, and patent Lemley willows, at $3 per M.

Column A is based on the system as practiced in New York S but should hold good for all regions under like conditions. The are supposed to be Welsh willow, and are taken at the usual cost Lyons, N. Y. While many holts are less highly cultivated. estimate may be taken as fairly representative of the average exp tures. From the figures it is seen that at the end of the third the initial expenditure is entirely repaid and a net gain made of per acre. A fair holt will average 4 tons of willow per year for t years after the second year. From the fourth through the fourte years the gain of $32.50 in the third year may be taken as an ave giving a profit of $357.50, or a total profit of $358.31 per acr the fourteen years of the existence of the holt. In order to fin net profit for the period the following should be deducted:

Rent at $5 per acre for fourteen years at 5 per cent	
Incidental expenses	
Total	

After the rods have been cut it is well to go over the holt and oroughly clean the stools, removing all rods that may have been ft. If the holt can be flooded, the water should be let in, cover-g the stools with a coat of mud.

One of the most successful ways of increasing the holt's vitality is let the rods stand occasionally for two years. The sixth and the nth years are good ones for leaving the holt uncut. Many growers ink that such a rest makes the subsequent crops brittle, but there nothing to substantiate such a theory.

PEELING, SORTING, PACKING, ETC.

The present system of drafting and peeling can not be much proved, but greater care should be taken in sorting. Almost all sket makers complain of the irregularity of American willow. At sent the rods are put into four sizes before they are peeled, and not sorted after they are white. A second drafting when they are t on the drying racks would be no difficult matter, and would doubtedly pay. The loss of weight in the hands of the manufac-ers comes from too early shipment after peeling, and under sent conditions is difficult to remedy. Anything which will ke his rods of superior quality should be attempted by the grower. is to his advantage to have his customers know him for his reli-lity and the superiority of his stock. If he can establish him- in a sufficiently close relation with them to enable him to work h them for the supply of such rods as are likely to be most in nand, so much the better for grower and consumer alike.

PENDITURE AND RETURNS IN AMERICAN WILLOW CULTURE.

In estimating the expenditure in willow growing, the holts on farm d and those on bottomland subject to inundation should be con-ered separately.

WILLOWS GROWN ON UPLAND.

In Table I the present and estimated expenditures and returns are en for willows on upland.

part due to the use of better varieties (American green, Lemle patent Lemley); it may be almost wholly ascribed to the fact th land is subject to overflow in the spring. This acts as fertilize builds up the soil about the stools.

TABLE II.—*Willow culture on bottomland subject to inundation.*

	A—Sap-peeled rods as grown in Maryland.			B—Sap-peeled be grown inches apart	
	First year.	Second year.	Third to fourteenth years.	First year.	Second year.
Annual expenses per acre.					
Share of $200 dam				$10.00	
Preparation of land	$25.00			25.00	
Sets	42.00			105.00	
Planting	5.00			14.00	
Mowings:					
Grass, at $8 each	16.00	$8.00	$8.00		
Vines, at $2 each	2.00	2.00	2.00	2.00	$2.00
Hoeings, at $4 each				16.00	8.00
Cutting:					
Salable rods, at $5 per ton	5.00	12.50	20.00	10.00	20.00
Left-over rods	1.00	1.00	1.50	1.00	1.00
Drafting, at $3 per ton	3.00	7.50	12.00	6.00	12.00
Peeling, at $10 per ton	10.00	25.00	40.00	20.00	40.00
Total	109.00	56.00	83.50	209.00	83.00
Annual returns per acre.					
White willow, at 5 cents per pound	37.50	93.75	150.00	75.00	150.00
Gross gain		37.75	66.50		67.00
Gross loss	71.50			134.00	
Amount of net loss for previous year, with interest at 5 per cent		75.08	39.20		140.70
Net gain			27.30		
Net loss	71.50	37.33		134.00	73.70

In Table II, column A shows as accurately as possible the pr cost of growing in Maryland. The rent has been taken at the no price which should be paid for bottomland in brush. It was f in many cases that willow growers were paying for ground other useless a rent which could hardly be obtained for the best tr gardening sites. Such a state of affairs had come about in c quence of making short leases or renting from year to year. (the land was cleared and in willows, growers would pay many t what they should rather than change or go out of business. Such ditions should not be considered in a normal expense account. F the present method of growing, a profit of $66.50 is made in the t year, as given in column A. The same will hold good for the eleven years, giving $731.50 for the period, or a total of $7 from the acre. Deducting from this fourteen years' rent, at $3 acre, amounting at 5 per cent compound interest to $58.80, and for incidental expenses, a net profit of $685 is obtained, or $48.93 acre per year for the fourteen years of the holt's existence.

periority of willows grown on bottomland has been explained
o the greater uniformity of moisture and the value of the
eposit of sediment. For this reason the building of a dam
te the water supply and drainage is urgently recommended
willow plantation of any considerable size. In column B the
re calculated on a basis of 27 acres and the cost of the dam

Estimating after the manner of the preceding columns, the
rn from the acre in twelve years will be $1,115.11. Subtract-
5 for rent, at $3 per acre for twelve years, with compound
it 5 per cent, and $20 for incidentals, there is a net return
of $1,047.36, or $87.28 per acre for twelve years.

SYSTEMS OF PEELING COMPARED.

paring the two systems of peeling at present in vogue in
a great difference in returns appears between willows
steam and for sap peeling. Practically the entire amount of
eled willow comes from New York. It seems strange that the
hich produces nearly half the value of the entire production
ca, and three-quarters of the actual amount grown, should
a cheap method when other districts get nearly four times as
their willows. Yet the matter is more simple than it seems.
k is the center of an old industry, where there is no skilled
d the willows are steam peeled to help make a cheap product.
uct of Maryland and Pennsylvania is sold to the makers of fine
nd furniture, and competes with the imported French willow.
must not be forgotten that the market for willows grown
to the estimates in Table I is much larger than that for the
of Table II. The market for willows which yield at present
an acre is a limited one, and if many growers take up the new
hich is estimated to give a return of $87.28 per acre, they
nt on a speedy fall in the price of raw willow. Yet the mar-
en $87.28 an acre and $50 an acre is amply sufficient to allow
tial fall in price and still give the grower a better profit than
w make by the present method of culture. Such a condition
the ideal to be striven for. If fine willows can be raised prof-
4 cents a pound, there is an import trade of nearly $40,000 to
red, together with the increase in the basket output which
llow a reduction in price of the raw material. These facts
nvince the willow grower that it is to his advantage to take
w method, and in the increased yield per acre and superior
f the stock to make a profit greater than that possible by his
d at a lower market price per pound. In practice the advan-
ttom over meadow land would be even greater than shown in
and III. The highland willows must be regularly fertilized

and the earth banked about the roots. They are subject
and to insect ravages, while those grown on land which i
inundated can be kept in better condition. For these r
average crop has been set at 6½ tons, a figure which resul
tainly justify.

The increase in yield by the new system is proportionatel
for willows intended for sap and for steam peeling, and th
methods must depend entirely upon the local market
conditions.

FIELD EXPERIMENTS OF THE FOREST SERVI(

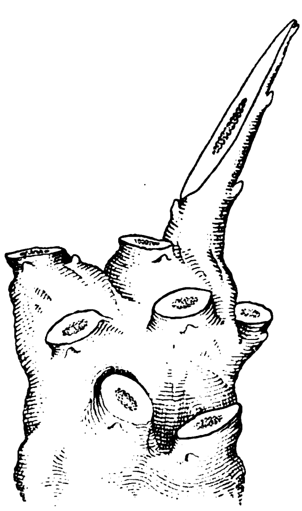

FIG. 19.—Example of good and bad methods of cutting.

In the seasons of 1903 and 1904 experimental plats of l
lows were set out on the Government experimental farm at
Va. The holt, which at present covers 66 square rods, is s
rich Potomac bottomland. The
green, patent Lemley, Lemley, a
willows are planted 18 by 6 inche
inches, and 36 by 12 inches ap
object of establishing this planta
determine the proportionate yield
willows under different systems o
and under similar soil conditions.

A number of new varieties were
from Europe and planted here d
spring of 1908 for the purpose of i
the varieties of basket willows su
cultivation in this country. Eac
will be planted in several spacings,
indicated, to determine the effect
and wide spacing on the yield an
life of the holt. The effect of lo
on the yield, character of the r
duced, and vitality of the stools, both in close and wide
will also be noted, together with many other important consi
to be included in these experiments. Careful study will be
the proportion of wood to bark and of the comparative
the peeled and dried rods for each species, variety, and stra

A number of experiments have been completed already
results published. The results of other experiments will
lished from time to time for the benefit of those engaged
willow culture.

A part of the willows grown each year is distributed, in
of cuttings and free of charge, to farmers and others d
establish basket willow holts.

WILLOWS FOR GROWING IN AMERICA.

The qualities required to constitute a perfect rod are extreme tough-ss, elasticity, a level, smooth, and brilliant white surface after peel-g, good splitting quality, freedom from branches, great length of oot in proportion to thickness, and a small pith. The development a species which will produce such rods and which at the same time hardy and not liable to ordinary diseases, and a good cropper, is e end for which growers should strive. This demands that the eatest care should be exercised, not only in the choice of species, t also in methods of culture. Good varieties give no results under reless methods; even inferior kinds will pay if well tended. It ould be the object of every grower to lower the price and better the ality of his willow, for on this depends the future success of Amer-n willow culture. If rods equal to the French and cheaper in price n be put on the market, there will be an opportunity for a great pansion of basket and furniture manufactures, and the growers l more than make up in larger sales what they lose in price per nd.

Of the 92 varieties of willow and hybrids known to European cul-e, the only ones extensively planted in this country are: The erican green or almond willow (*S. amygdalina*), the purple or Welsh low (*S. purpurea*), and the Caspian or Lemley willow (*S. pruinosa tifolia*). It is worth while to describe these in some detail.

(1) The almond willow (*Salix amygdalina*, fig. 18) is the most widely tivated willow in the north of France, and is much used in England d Germany. The growers in Maryland and Pennsylvania also w it under the name American green. The wood is strong and avy, so that basket ware made from it is very durable—an impor-t point in competition with rattan. It is also easily bent, tough, d not difficult to split, and its color is a brilliant white. Yet it is t as easily used for coarse work as for fine, and for "brown" or peeled as for peeled basket ware. Some of the shoots are heavy ugh to be used for the heaviest baskets; others are good for fine kmanship. Although the almond willow prefers a heavy land, it s well also on sandy soil. It demands, however, a soil full of rishment. It has the heaviest foliage of all willows. This great area makes vigorous growth possible, and in the fall covers the h with litter. Consequently weeds have the least chance to grow, le the heavy shade keeps the ground fresh and unburnt. One of most serious faults of this willow is a tendency to branch, a peculi-y of certain other varieties in varying degrees, and which may reduced to a minimum in all cases by close planting. It is also re sensitive to damage by hail than any other willow, wart-like rescences or black spots forming on the places struck by hail-

stones. It is cultivated in Maryland, Pennsylvania, through Indiana, Ohio, and Kentucky, and as far as Illinois, and everywhere is in high demand, especially for furniture.

(2) *Purple or Welsh willow* (*Salix purpurea*, fig. 16).—This is perhaps the most beautiful of all the willows. It produces a large number of supple, slender, and even-sized shoots, with no tendency to branch. It grows slowly, however, and never attains a great size. The rods are very difficult to peel, and the wood is extremely hard, of a bad color, and not easily split. The ground most suited to its growth is a fresh sandy loam with considerable humus. On heavy land it does poorly. The purple is the hardiest willow known. Cold and heat, wet and excessive drought—all these extremes have less effect on its growth than on any other basket willow. It is also a good cropper; holts have often been cut forty years. It is the most commonly grown willow in America.

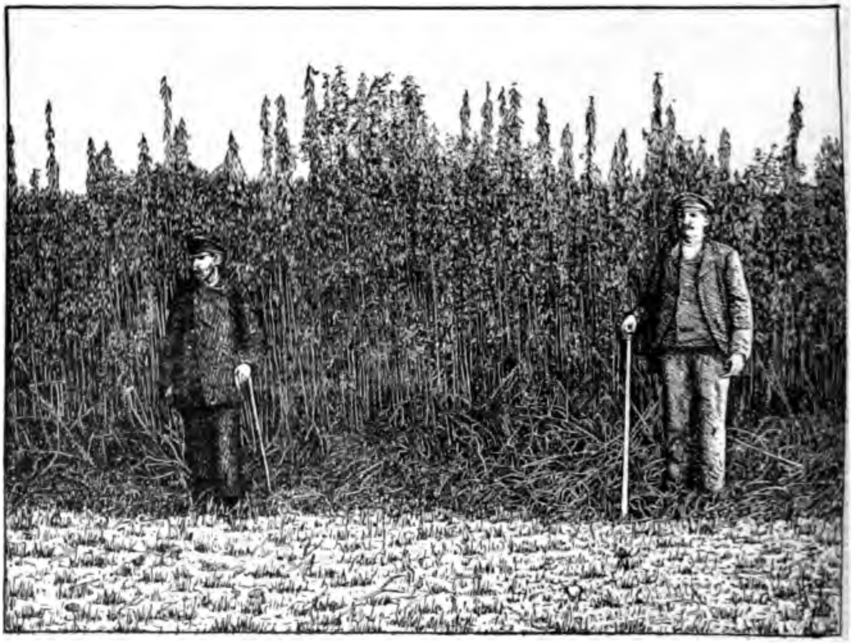

FIG. 20.—First-year rods of common white willow from newly planted sets. Germany, November, 1902.

(5) *Lemley and patent Lemley, or Caspian willow* (*Salix pruinosa acutifolia*, fig. 17, *and variations of the same*).—The Lemley has been much recommended for planting on sandy soil, where it is said to do better than any other willow. It is a serviceable species and gives good rods, which peel well and are white. As it sends out very few rods from a stool and has a tendency to branch, it should be planted in close order. With its hybrid, the patent Lemley, it is common and highly valued in parts of the willow-growing district of America.

NUFACTURE OF WILLOW WARE IN THE UNITED STATES.

GENERAL REMARKS.

Europe to-day every grade of basket, from the finest to the sest, is made of willow, and of almost nothing else.[a] The heaviest baskets and receptacles used for handling rough merchandise are e out of unpeeled willow, and from this its use extends through he grades of basket ware—peeled willow market, clothes, and fruit ets, furniture, hampers, and trunks, to the finest examples of split w ware, wrought with a skill which gives them a real artistic e.

America the market has a different aspect. Here a very large ber of baskets are made of wood, some of woven pine, oak, ash, elm strips, others constructed from broad veneers laid together at bottom and fastened at the rim by a strip. Market, clothes, and dry baskets are largely made of wood, and the willow is forced to ontent with a limited share of the general trade. Rattan, too, always enjoyed a high degree of favor, and has a permanent place e American market. Baskets made from wood other than willow much less durable and have not the combined lightness and elas- y which is so desirable. Rattan is quite as lasting as willow, but less rigid, and its rough surface soils quickly. It is also much expensive.

this continent, where economy of labor is of the first importance, manufacture of those baskets intended to be filled but once, such uit baskets, etc., forms a class by itself, which lies necessarily ely outside the field of the willow. In this case cheapness is the essential, and the preparation of the material is entirely done by matic machinery, while the hand process of manufacture is the lest imaginable. A recent machine has entirely supplanted hand r and reduced the cost.

WICKER FURNITURE.

r many years, huge quantities of rattan have been used in the ufacture of furniture. In consequence a high degree of skill has evolved, and the designs have become more and more elaborate. ow is less easy to work, the result being that furniture made from s greater simplicity of design. This, together with its durability, ness, and beautiful color, has brought it into popular favor, and y important manufacturers have given up rattan entirely and gone to willow. As a consequence the output has increased more than per cent in the last ten years.

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very small quantity of wooden-strip baskets is manufactured in Sweden and ay.

The manufacture of willow furniture requires a high degree of skill. (Figs. 21–22.) The lower cost of the willow is neutralized by the greater difficulty in working it, so that the two kinds of furniture enter the market on equal terms. Willow furniture is also made in Europe, but it is bulky and the transportation is very costly. As a result the import is not worth considering.

The industry in America is centered in New York and Boston. There are small concerns in various other places, but all the wholesale supply comes from a few large houses in these two cities. Wages are as high as $20 a week, but most of the workmen are foreigners; few young Americans adopt the trade, although really first-class men can always find work even at $3 per day. If the industry increases as it gives promise to, one of the greatest problems will be that of skilled labor.

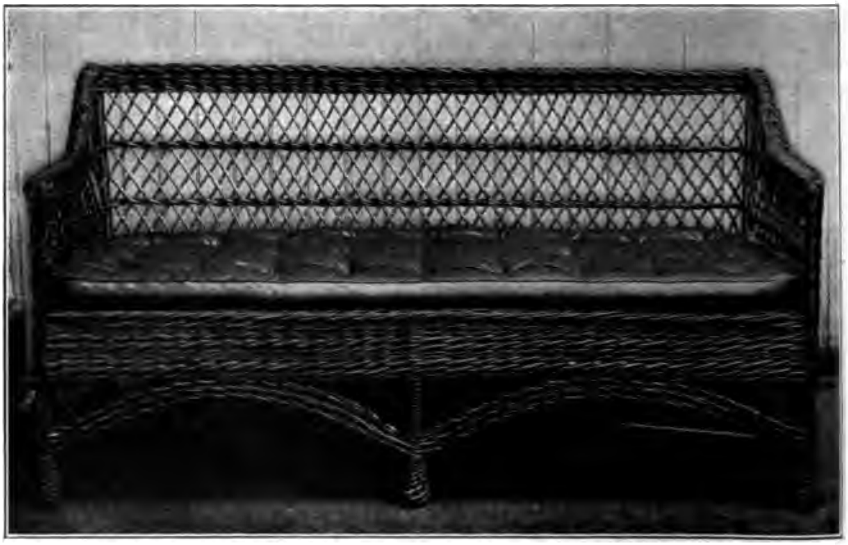

Fig. 21.—High-grade willow furniture.

Yet the question of the raw material is of even greater economic importance. At present all furniture makers use far more French willow than they do American. There are several reasons for this. The French willow is of a much more beautiful color, and is better sorted and easier to get in small sizes. The American is sorted and packed with less care, and the rods are apt to be large, the average grower not appreciating the value of small stock. The latter is more difficult to peel, and consequently more expensive to produce. As a result it is generally discarded, although there are growers who supply small rods at cost price just for the sake of the trade.

[he average price for French willow is about 7 cents per pound. erican willow of the best quality comes in four sizes, and is sold at m 5 to 7 cents a pound. The smallest size is hard to get, and the er sizes are not satisfactorily sorted.

emembering that American willow is favorably looked upon by niture makers and that most of their objections can be removed greater care in its culture, every effort should be made to obtain session of this most favorable market.

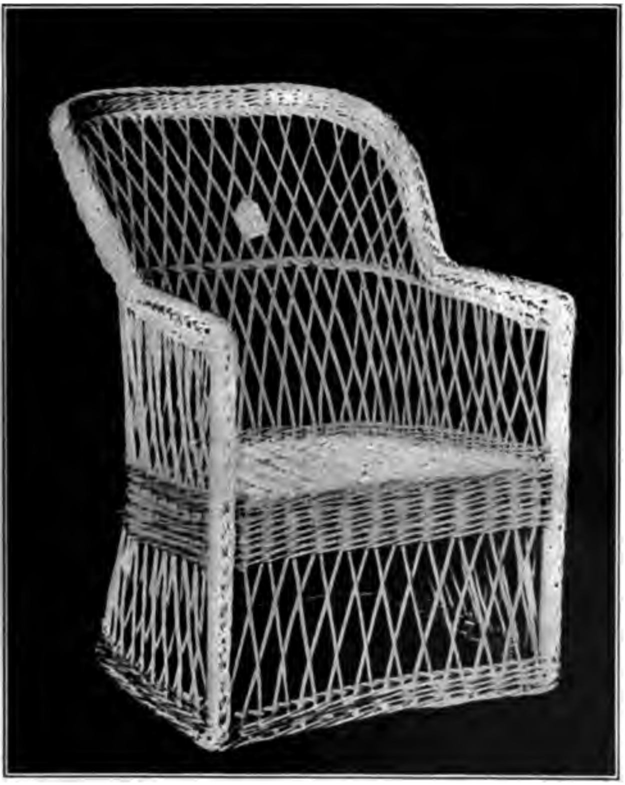

Fig. 22.—High-grade willow furniture.

HIGH-GRADE WILLOW BASKET WARE.

he makers of high-grade willow basket ware are generally in the ger cities. Through thrift, industry, and perseverance they have ilt up a regular custom trade. (Fig. 23.) Their establishments found throughout the North, from the Atlantic to the great cities the Mississippi. High wages in the far West make it more profitle to buy in the East, although there are several establishments in n Francisco and Sacramento. In the South, where large cities are fewer, such basket makers are to be found only in Richm Charleston, and New Orleans.

Almost without exception these workmen make no attempt to pete with the manufacturers of cheaper baskets, and confine t selves entirely to the production of goods for their particular tomers.

One of the most serious questions which this phase of basket m must contend with is labor. Even in New York and Boston diffi is found in getting good men at the wages which the basket make pay, and the farther west one goes the greater is the lack of hands. The men available are nearly all foreigners, mostly Ger

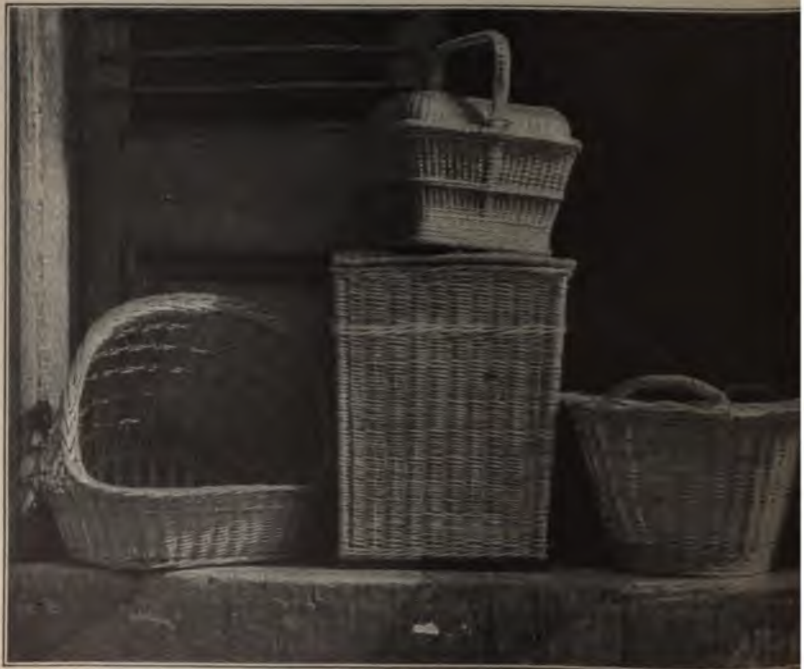

FIG. 23.—High-grade willow ware.

Occasionally American-born workmen are to be found, but the l hours and comparatively small wages ($2 a day is a maximum) d young men into other and more attractive fields. Throughout country there is many a master basket maker who could enlarg trade if he could secure more labor. As it is, he must be content hold what custom he has.

The source of supply of raw material varies in different parts of country. In the East both foreign and domestic willows are lar used. The large furniture makers of Boston and New York manufacture baskets, and for their best wares use French stock. T is done for the same reasons as those given in the case of willow furniture. Nevertheless they all use American willow and say they would use more if they could buy it, as it is heavier and more durable than the French. All willow used for fine baskets, and still more so for furniture, must be brilliant white, and for this reason only sap-peeled rods are to be considered. The foreign willow at present has a better color, but for basket ware American sap-peeled willow is white enough, and if it is properly sorted, not branchy, and with long, straight rods, it answers every purpose of the trade.

There is no reason why the custom trade of the great eastern cities should not be supplied by home growers who take the time to improve their methods. Baltimore is the seat of a large number of expert basket makers, who are almost entirely supplied by the willow growers of the neighborhood. Richmond is supplied by an establishment which has taken the wise step of growing its own willows, and with the most gratifying result. Indeed, these two cities, with their supply of raw material near at hand, are able to ship high-grade baskets to other parts of the country, and afford a very instructive example of what may be done in this line.

As one travels farther west the transportation cost raises the price of foreign willows, so that even in Cincinnati it stands at 7 to 8 cents a pound. As the best native stock of the neighborhood costs but 6½ cents and lower grades only 4 or 5 cents, it needs only quality to command the field. In Indiana, Ohio, and Kentucky the question is entirely one of better growing and a successful contest with dangerous insect pests. A few years ago the best willows sold at 3 cents a pound, but now can hardly be bought at 6. Some of the larger basket makers in St. Louis use French rods, but the vast majority of the stock comes from the neighboring willow-growing States. Chicago is supplied with a very good willow from Wadsworth, Ill., and from Indiana and Kentucky. The same is true of Milwaukee and other cities in the same district. One and all, the basket makers seem to prefer the American willow if it can be obtained.

The custom-made basket has a steady market throughout the country. If the basket maker can get good stock at a low price, there is no doubt but that he can enlarge his trade. For this reason there is a promising outlook for scientific willow culture.

LOW-GRADE WILLOW BASKET WARE.

The best quality of willow basket, it has been seen, has scarcely a competitor in the field. The demand for such goods, however, is comparatively limited. The great mass of the population are either unable or unwilling to pay a high price for household basket ware. It is to satisfy this demand that the wooden basket exists and has so large a sale. Nevertheless willow is known to be so superior to it for hand baskets, clothes baskets, hampers, etc., that people will buy it in preference if its price reaches a figure which represents, in comparison with the cheaper forms of basket ware, the ratio of durability between the two. To bring prices to this level has been the attempt of a large section of the basket-making population for many years, and upon them alone falls the brunt of the competition with wooden baskets, and also with the cheap willow product imported from Europe.

In order to gain a clear view of the situation, it is necessary to divide the manufacture of cheap willow baskets into two sections. The first of these is the wholesale basket industry in western New York State and the second the manufacture of cheap baskets in small isolated establishments in the great cities and throughout the country.

The basket industry about Syracuse, Rochester, and other western New York cities is different from that in any other part of America, and more nearly approaches that of certain sections of Europe. It is centered in the midst of an important willow-growing district, and is mainly in the hands of a few large dealers. These men buy the willows and give them out to the basket makers, who make them up into baskets at home, receiving a specified sum per dozen, according to size. The principal object in view is cheapness, and everything is done to reduce the cost to a minimum. The willows are steam peeled, a process which very much reduces the price, but which turns the rods a red-brown color and ruins them for all manner of fine work. There is no doubt whatever that it is European competition which sets the price of this basket ware, and which has reduced the New York basket industry to such a low margin of profit that its very existence is threatened. Certain large importing houses in New York have buyers continually in Europe, who procure large quantities of cheap wares at every opportunity. These baskets can be compactly stored and shipped at low rates, the import duty paid, and the goods put on the American market at a phenomenally low price.

The competition of the foreign basket is illustrated by the case of the willow growers and dealers of Syracuse, who about fifteen years ago, favored by the cheap price of willows, formed themselves into a stock company and began to assume control of the trade in America. Immediately the importers bought up a large stock of cheap baskets in Europe, underbid the American combination, and deprived them of their sales. The large number of baskets left over in the warehouse at Liverpool was set on fire—probably by those who feared for their next year's work—and since that time no attempt has been made at combination. To make matters worse, at that time the willows were sadly devastated by insects and the price of the raw material was consequently very much increased.

Although the import of foreign baskets sets the price of the American-made product, this import itself is not a growing one. The whole consumption of basket ware in America is not increasing, and besides, the foreign basket, to sell at so small a price as it does, must necessarily be of very low quality. For this reason it has lost favor, and the American basket is beginning slowly to assert itself. Certain basket makers even in the New York district sell their product for much more than the European basket ware brings. This is an approach to the class of the high-grade basket, but as yet the tendency is not marked; the great mass of the workmen are in active competition with the European product, because, even if it is not largely imported, it is always overhanging the market and preventing any rise in price. Nor is this the only depressing force which the cheap American basket must face in seeking a market. Certain grades of wooden baskets actively encroach on its field. Huge quantities of covered hand baskets are made of splints at a very low cost, and have a large sale. A wooden "satchel basket" can be bought for 70 cents, while a willow one of equal capacity costs $1.25 to $1.50. The willow basket is much more durable than the wooden one, but not enough so to make up for the difference in price. This is the case not only with hand baskets, but also with clothes, market, and bushel baskets. It may safely be said that the entire decrease in the willow basket output since 1890 has gone to swell the sales of the same article made of wood.

Nevertheless, the cheap grade of willow basket has a regular place in the market, and one necessary to the general trade. A reduction in the cost of the raw material would allow the dealer to pay a better price for making the baskets. Nor need this reduction in the cost of the raw material be carried out at the expense of the farmer. More scientific methods, a greater yield per acre, and a better knowledge of his market will give him a larger profit on his willows in the increased demand.

Although nowhere else is there so large a center as in western New York, there are basket makers scattered through the country districts of Pennsylvania and the Middle Western States as far as the Mississippi. These work under very much the same conditions as their colleagues in New York, using, as a rule, however, sap-peeled willow. Apart from a small sale in their neighborhood they all sell to the nearest large city, and here they invariably meet the French or German basket on sadly unequal terms. In Cincinnati, for instance, the large dealers can afford to sell a "nest" of four foreign baskets (three pecks, a half-bushel, a trifle more than a peck, and a half-peck) at 64 cents, while the American maker loses money by selling better made baskets for less than 90 cents, although he is compelled to sell at this price if he sells at all. Thus it is throughout the country.

In all the large towns small basket makers are found who sell low-grade baskets at a very low price. They are almost always foreigners who live in the simplest way and in the smallest space possible. Their material they obtain as cheaply as they can, and with the help of their whole families and by working long hours they are able to produce baskets which they sell in their neighborhood or peddle in the streets, probably making a very good profit. From this laborious, frugal class of foreigners have come nine out of ten of the successful, well-to-do master basket makers.

SUGGESTIONS FOR BASKET MAKERS.

In Europe basket ware is used for many purposes practically unknown in this country. In dairies and bakeries on the Continent and in England, eggs, buns, rolls, etc., are displayed in very delicately woven shallow baskets of the finest kinds, which are very beautiful and make the store much more attractive than ordinary vessels. Grocers often use willow hampers for dried fruits, nuts, etc. The hampers are made with one side higher than the opposite, so that the wares can be better seen. The hamper is set on short feet to keep it off the ground.

In England great quantities of split willow ware are used. Screen doors and office window screens are beautifully fashioned in willow, and even hotel washstand splashers are made out of the same material. Beautiful little mats for hot dishes at table are also made from split willow, to say nothing of very dainty bread baskets.

A half-bushel basket is made in England and Holland which is singularly durable for its weight. The bottom is arched, giving the whole basket great strength. Nurserymen ship their trees in baskets of unpeeled willow, the uprights of which project from the basket and are tied together over the top of the plant for its protection.

A very beautiful and light basket is made in Germany, with the sides formed simply of uprights strengthened by one or two single lines of weaving.

In England commercial travelers' sample boxes are made of willow, lined with waterproof leather or canvas, the corners and edges bound with rawhide. These trunks are very light, and are serviceable enough for almost any usage. Laundry hampers are also made on the same principle. Parcel trucks on the English railways are almost always of willow, and seem to render perfect service. Willow trunks and hampers are a feature of European traffic, and their use, particularly for suburban transportation, might become more general here.

SUMMARY STATEMENT.

The growing of basket willows was introduced into the United States some sixty years ago by German immigrants who settled in New York and Pennsylvania. The industry was soon extended to

Maryland and westward to Missouri and Iowa; it is now rapidly spreading over the nonarid regions of the far West. This industry, which has been languishing for a number of years, has recently taken a sudden leap and shows enormous possibilities. This is due entirely to improved methods of culture and to the introduction of new and choice varieties of basket willows The cost of production in the United States has been greatly reduced, while the quality of the rods has been improved. These results have brought a betterment of the condition of both the grower and the manufacturer.

In summarizing the essential considerations of this industry, it is important to call attention particularly to the specific instructions given in the bulletin regarding the planting, cultivating, harvesting, and marketing of basket willows. General instructions do not always apply to the special needs of some growers. Many details can be learned only by experience.

Soil and situation.—Great care should be taken in the selection of the soil and the location of the holt. Rich, permanently moist, sandy loam gives best returns, though ordinary moist sandy land often yields profitable crops of willows. Poor soils produce paying crops where there is a market for short rods. Avoid land on which water is stagnant during the summer. If by drainage the water level on such land can be lowered at least 6 feet below the surface, the situation may be considered appropriate. Do not plant willows in localities where early frosts occur. The tender shoots are easily injured by cold.

Preparing the ground.—Plow 10 or 12 inches deep in the fall, prior to planting the following spring. This turns the top layer of the soil so deep that weed seeds can not spring up. If rain is insufficient, irrigate the holt, if possible, but thorough drainage must be provided, as water must not stand on the surface. It is best also to keep the land well drained during the winter.

Variety and quality of willows.—Returns depend very largely upon the method of culture, but more upon the variety of willow planted. Willows with the most approved qualities should be planted, because the shoots of even the best varieties and in the most suitable soil grow brittle after the stools become old. The American green and Welsh willows are most generally planted. The rods of the former peel readily, split easily, are snow-white, hard, flexible, and heavy. They have a tendency to branch, however, and unless the stools are planted close together, a large percentage of the rods branch so much that they are often unfit for peeled stock. The Welsh willow yields less in bulk per acre than the American green, but surpasses the latter both in market value (because of better quality) and in specific weight. For planting along rivers to prevent erosion, Welsh willow is the best. The Lemley, or Caspian willow, is prefer-

s thereafter, because the weeds are completely shaded out by the
› leaf development. Bind weeds and wild morning-glories are
troublesome in most holts, and must be removed. The holt can
›e cultivated too often so long as the stools and shoots are not
ed by the cultivator.

rvesting the rods.—The best time for cutting the rods is between
›mber 15 and February 15. Rods from one-year-old holts
ld be cut at the end of the first year, preferably when the ground
›zen. During the first year the root system is small and care
be taken in cutting not to pull up the stools. Keep knife sharp
make the cutting strokes clean and decisive. Cut close to the
s—but not into them.

›ds to be peeled are stood on end in a pit containing water from
6 inches deep and kept there until the sap rises (the buds open
leaves appear), when the bark can be removed. The peeled
are quickly bleached and dried when exposed to the sun, after
h they are sorted, tied in bundles, and stored in a dark, dry
. Frequently willow rods are steamed or boiled in water for
or four hours as a means of preparing for peeling, a method
h loosens the bark and renders the peeling easy. Boiling or
ning gives the rods an undesirable dark buff color which makes
less valuable.

›ds are peeled by drawing them through a springy wooden or
fork, shaped like a clothespin (fig. 10, 1–7), but larger. This
ns the bark in strands so that it can easily be removed by the
s.

rketing willows.—Peeled rods may be sold to local basket
ers or to large willow-ware makers, who are usually glad to buy
-grown instead of imported stock. For the larger market the
must be white and properly sorted according to sizes in order to
›ete with the imported stock, which is of good color and con-
of long, straight, branchless rods, carefully sorted into equal
hs and into grades of uniform quality. Those who sell to local
et makers are able to offer them at a lower price than those who
to ship to a distant market. The grower who sells to local
umers can also keep in constant touch with his customers and
r more successfully to their requirements in special varieties and
les of rods than can the grower whose product goes to larger
kets.

pon application, the Forest Service, Washington, D. C., will fur-
to willow growers the names and addresses of the manufacturers
illow ware nearest to them.

FARMERS' BULLETINS.

following is a list, by number, of the Farmers' Bulletins available for distribu-
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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 342.

Experiment Station Work,

XLIX.

Compiled from the Publications of the Agricultural Experiment Stations.

CONSERVATION OF SOIL RESOURCES.
POTATO BREEDING.
DISK-HARROWING ALFALFA.
THE MONTREAL MUSKMELON.
STORAGE OF HUBBARD SQUASH.
FIG CULTURE IN THE SOUTH.
MUSHROOM GROWING.
PRESERVING WILD MUSHROOMS.
COOKING BEANS AND OTHER VEGETABLES.
A MODEL KITCHEN.

NOVEMBER, 1908.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
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1909.

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- Kentucky—*Lexington:* M. A. Scovell.[a]
- Louisiana—
  - State Station: *Baton Rouge.*
  - Sugar Station: *Audubon Park, New Orleans.*
  - North Louisiana Station: *Calhoun;* W. R. Dodson (*Baton Rouge*).[a]
- Maine—*Orono:* C. D. Woods.[a]
- Maryland—*College Park:* H. J. Patterson.[a]
- Massachusetts—*Amherst:* W. P. Brooks.[a]
- Michigan—*East Lansing:* R. S. Shaw.[a]
- Minnesota—*St. Anthony Park, St. Paul:* E. W. Randall.[a]
- Mississippi—*Agricultural College:* W. L. Hutchinson.[a]
- Missouri—
  - College Station: *Columbia;* H. J. Waters.[a]

Missouri—Continued.

  - Fruit Station: *Mountain Grove;* P. Evans.[a]
- Montana—*Bozeman:* F. B. Linfield.[a]
- Nebraska—*Lincoln:* E. A. Burnett.[a]
- Nevada—*Reno:* J. E. Stubbs.[a]
- New Hampshire—*Durham:* E. D. Sanderson.[a]
- New Jersey—*New Brunswick:* E. B. Voorhees.[a]
- New Mexico—*Agricultural College:* L. Foster.[a]
- New York—
  - State Station: *Geneva;* W. H. Jordan.[a]
  - Cornell Station: *Ithaca;* L. H. Bailey.[a]
- North Carolina—
  - College Station: *West Raleigh;* C. B. Williams.[a]
  - State Station: *Raleigh;* B. W. Kilgore.[a]
- North Dakota—*Agricultural College:* J. H. Worst.[a]
- Ohio—*Wooster:* C. E. Thorne.[a]
- Oklahoma—*Stillwater:* B. C. Pittuck.[c]
- Oregon—*Corvallis:* J. Withycombe.[a]
- Pennsylvania—
  - *State College:* T. F. Hunt.[a]
  - *State College:* Institute of Animal Nutrition, H. P. Armsby.[a]
- Porto Rico—*Mayaguez:* D. W. May.[b]
- Rhode Island — *Kingston:* H. J. Wheeler.[a]
- South Carolina—*Clemson College:* J. N. Harper.[a]
- South Dakota—*Brookings:* J. W. Wilson.[a]
- Tennessee—*Knoxville:* H. A. Morgan.[a]
- Texas—*College Station:* H. H. Harrington.[a]
- Utah—*Logan:* E. D. Ball.[a]
- Vermont—*Burlington:* J. L. Hills.[a]
- Virginia—
  - *Blacksburg:* S. W. Fletcher.[a]
  - *Norfolk:* Truck Station, T. C. Johnson.[d]
- Washington — *Pullman:* R. W. Thatcher.[a]
- West Virginia—*Morgantown:* J. H. Stewart.[a]
- Wisconsin—*Madison:* H. L. Russell.[a]
- Wyoming—*Laramie:* J. D. Towar.[a]

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[a] Director.

[b] Special agent in charge.

[c] Acting director.

[d] Superintendent.

EXPERIMENT STATION WORK.

Edited by W. H. **Beal** and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled 'om the published reports of the agricultural experiment stations and kindred istitutions in this and other countries. The chief object of these publications to disseminate throughout the country information regarding experiments at ie different experiment stations, and thus to acquaint farmers in a general ay with the progress of agricultural investigation on its practical side. The esults herein reported should for the most part be regarded as tentative and iggestive rather than conclusive. Further experiments may modify them, and cperience alone can show how far they will be useful in actual practice. The ork of the stations must not be depended upon to produce "rules for farmig." How to apply the results of experiments to his own conditions will ever emain the problem of the individual farmer.—A. C. **True**, Director, Office of xperiment Stations.

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EXPERIMENT STATION WORK.[a]

CONSERVATION OF SOIL RESOURCES.[b]

The conservation of the natural resources of the soil constitutes ne of the elemental problems of modern scientific agriculture.

In the United States agricultural operations have generally been onducted without much consideration for the soil inheritance of uture generations. Lands have been denuded of trees, and the soils ius more or less exposed have in many localities been washed by orrential rains or melting snows into the rivers, leaving bare rocks ehind or soils too deficient in plant food for profitable agricultural urposes. Indifferent methods of cultivation have produced effects milar to those caused by deforestation. In some places rains have equently washed soils improperly cultivated, while in others winds ave drifted the soils, so that at the present time the problem of conrving what is left of the natural resources of the soil is of great onomic significance.

The agricultural experiment stations have made efforts to work ut the best methods of conserving the natural resources of the soil. vast amount of work has been done to improve excessively cropped r washed lands by means of the scientific application of fertilizers nd the growing of green manures. This, however, is a work of oil building rather than of conserving the forces already in soils, ut the following statement of experiments shows that the stations have long been engaged in work looking to the scientific conservation of the natural resources of soils. In this article attention is directed solely to soil conservation as a basis of agriculture, and no consideration is given to the work done by the stations in the conservation of the moisture and plant-food contents of soils.

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[a] A progress record of experimental inquiries, published without assumption f responsibility by the Department for the correctness of the facts and conlusions reported by the stations.

[b] Compiled from Alabama Tuskegee Sta. Buls. 6, 11; Mississippi Sta. Buls. 9, 66, 108; South Carolina Sta. Bul. 32; Tennessee Sta. Bul., Vol. III, No. 4; Visconsin Sta. Bul. 42. See also U. S. Dept. Agr. Farmers' Buls. 245 and 327.

PREVENTION OF SOIL WASHING.

Soil washing occurs on rolling lands and is generally the result of heavy rains falling on cultivated fields after crops have been removed. The steeper the grade the deeper, usually, are the washed-out gullies, so that after a few years of such washing soils are largely carried away, leaving only bare rocks, a slightly fertile subsoil, or, at best, a soil only a few inches in depth. Such lands are known as " washed " or " galled " lands.

There are various ways for preventing surface washing, such as embanking, tile drainage, deep culture, subsoiling, sodding, and planting to crops.[a] But when soils are washed, two methods of reclamation are generally practiced. The first step is to eliminate the gullies for the better working of the land. This is accomplished by filling with stumps, brush, and an occasional load of earth, and briars and other plants will grow in them. Finally, by plowing and a few embankments, if necessary, the surface can be made smooth by the time the soil is ready for cultivation again. The land is now prepared for the prevention of washing. Observations have shown that plant growth prevents the washing away of soils, and the laying down of such fields in permanent pasture is one method of overcoming the difficulty of washing. Even " the losses which are sustained through the leaching of underground water may be largely prevented though not entirely. This loss is best prevented by keeping the ground always covered by a growing crop, especially during the fall and winter, when this loss is likely to be greatest. Organic matter and clay have a tendency to fix the plant-food ingredients and prevent their being carried out by the water, and this is the reason that land with a clay subsoil is well adapted to improvement."

Under the conditions which exist, however, in soil-washing regions, the securing of a stand of crops on such lands is an exceedingly difficult undertaking. The Tennessee Station made a large number of experiments during the years 1878 to 1890 with many crops to prevent the washing of the embankments as well as the soil between embankments. Most of these experiments resulted in failure, but the following is a noteworthy exception, as described by the investigator:

> Becoming convinced of the great value of mulch in saving young grass and clover from being scalded out on raw clay exposures during summer, * * * all the sedge grass, weeds, etc., on the place [were] mowed down and stacked up for that purpose during the fall of 1889. During this fall also and the winter succeeding * * * the galled places on the farm not already under treatment were leveled, plowed, subsoiled, and manured at the rate of 20 good

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[a] For descriptions of methods of preventing soil washing by means of graded embankments, level embankments, and so-called terraces, see Alabama Tuskegee Sta. Bul. 6, pp. 4, 5; Mississippi Sta. Buls. 66, pp. 13-18; 108, pp. 4-11.

loads of manure per acre on the surface. In the spring of 1890 this was thoroughly worked in with harrow and the whole seeded to clover 6 pounds, red top 1 bushel, bluegrass 1 bushel per acre, with 100 pounds good complete fertilizer per acre. This seeding was killed by a March freeze, and it was reseeded as before, but without any more fertilizers. In May the whole was carefully mulched with sedge grass.

The result was considered a decided success, and the conclusion was that while rather costly, the method altogether, perhaps, furnished the cheapest and most satisfactory means of reclaiming galled hillsides.

Probably the most effective method of conserving the natural resources of washed lands is by means of terracing. Three methods of terracing land have been developed. One is to have a system of level embankments about 4 feet wide and 18 inches high, the rows to be run as near on a level as possible and parallel to the embankments. This method is employed where both the surface and subsoil are porous and absorb water rapidly. It aims to hold the water practically where it falls until soaked up by the soil.

A second system of terracing proceeds on the basis of letting the surplus water run, but by means of rows and embankments make it run slowly. To accomplish this each embankment and each row is given a little fall, the embankments being required to do the bulk of the work. To make this system operate satisfactorily there should be two systems of embankments, the rows running parallel to the main embankments and crossing the shorter ones.

A third system aims at producing, by the method of plowing, real terraces or comparatively level areas on the side or slope of the hillside. To accomplish this lines of level are run the same as in system one, but no embankments are made. A hillside plow that turns all furrows downhill is always used in breaking. Wherever the lines of level have been run, leave an unplowed space 12 to 15 inches wide at each plowing. Let the soil of the first furrow in each terrace space be turned onto the unplowed space, thus elevating this space. If the plow breaks 6 inches deep, the grade or fall of each terrace space or area will be reduced 1 foot every time the land is broke. In carrying out this system the rows are run on a level. It only differs from the system first described in not making an embankment to start with and in the use of hillside plow in breaking.

The perpendicular fall between these terraces should be about 4 feet, and the same is true of the system of level embankments first described. Where both the embankments and rows are given a fall, as described in the second system, the perpendicular fall between embankments may be 8 feet.

The second system, with embankments and rows having a small fall to conduct surplus water slowly, is in use on the [Mississippi] Station grounds. The embankment is essentially a very much enlarged hillside ditch, the bottom of which being 4 to 6 feet wide and the bank from 4 to 6 feet wide and about 18 inches high. This broad, shallow ditch and broad embankment can be crossed with rows and implements and so cultivated as to lose very little land and can be kept as free from weeds and grass as other parts of the field.

The Mississippi Station has reported data as to the cost of making terraces and filling gullies. The former averaged $0.07 per rod, while all the gullies, large and small, on a badly washed hillside were filled for $5.62 per acre. When it is considered, therefore, that land otherwise useless can be brought under cultivation at a cost of a few dollars per acre, and that by proper care thereafter this land can be kept in good condition with little expenditure of money and labor, the first outlay seems very insignificant compared with the great wealth-producing power thus afforded to a community by these means of conserving the natural resources of the soil.

PREVENTION OF SOIL DRIFTING.

Light sandy soils and sandy loams are often destructively affected by winds. Large tracts of land have been rendered practically useless for the growing of crops, and crops growing in fine condition have been ruined by the drifting of the soil. These conditions apply in many western States where large areas of land covering hundreds of square miles, which experience has proven to be capable of profitable cultivation, are subject to the destructive effects of winds.

The physical explanation of these phenomena is given by Prof. F. H. King as follows:

> Long continuous fields of dry, naked, sandy soil, in hot weather, have a peculiar effect upon the air currents sweeping across them. The sand itself becomes very hot and greatly expands the air coming in contact with it, making it relatively lighter than the colder, much more rapid current of air sweeping along above, and the result is the warm air suddenly blisters, as it were, and being lifted from the ground, a cold current of rapidly moving air from above strikes obliquely upon the surface, raising a cloud of fine dust into the upper swifter current in which the particles are borne away, while the coarser grains are rolled along the surface until the air is slowed down by its friction upon the ground. This air coming down from above has a peculiar parching effect, too, for it is naturally drier than the ground air and, striking the hot soil, its parching power is greatly augmented by the heat it so receives. Grass-covered surfaces and damp soils do not become overheated as the dry sands do, and the result is, during windy times, the air moves across them in a more steady and less turbulent manner.

In consequence of such conditions occurring over extensive areas of soil in parts of Wisconsin Professor King, of the Wisconsin Station, made a careful study of the influence of shelters and methods of cultivation as means of protecting the fields. From these investigations the following practical suggestions are made regarding the conservation of these lands for agricultural purposes:

1. **Frequent rotation in long, narrow lands.**—If light soils are cultivated in long, narrow lands, not wider than 15 to 20 rods, alternating with similar strips of grass, preferably clover, such destructive effects as above indicated can not occur, or only to a slight extent. If possible, the fields should extend in a north and south direction rather than east and west. The nature of the lands renders cultivation

one way satisfactory and a saving of labor. The rotation should aim "to always have in the spring a field of grass to the west of those which are to be sowed to grain and seeded to clover, and this is secured by always planting potatoes or corn on clover sod, for the latter going in later in the season allows the clover to stand as a protection while the grain is getting started when the most serious damage is done and at the same time furnishes a green manure to plow in to increase the humus of these soils, in which they are naturally so deficient."

2. Increasing the water-holding power of the soil.—The small water-holding power of these soils is the cause of drifting, and makes it difficult to get and maintain a good stand of clover. Moreover, the more these fields are allowed to drift the less their water-holding power becomes and the greater their tendency to drift in succeeding years. The presence of organic matter in the soil increases its water-holding power, so that the use of plenty of barnyard manure and the plowing under of green crops and weeds are recommended.

3. Leaving the ground uneven after seeding.—The smoother the ground the greater is the velocity of the wind close to the surface and, therefore, the greater is the power of the wind to take up and carry away the soil particles. Observations show that fields left smooth after seeding drift badly, while in uneven fields there is no appreciable drifting. Running a harrow over smooth fields stops drifting at once where the soil is stirred. Sowing the seed with the drill north and south also has a tendency to lessen drifting very materially.

4. The preservation of wooded belts in north and south strips.—Where clearing is being done, strips running north and south should be left as windbreaks to stop the drifting and to make sure a crop of clover or grass. "The width of the wooded strips to be left as hedgerows would depend upon the character of the soil and upon the width of the strips that are cleared; the lighter the soil is and the wider the cleared fields the broader the hedgerows should be."

5. The planting of windbreaks.—Planting of trees on the section and quarter section lines of prairie lands, on roadsides, along the borders of fields, and as shelter belts on light lands that have been entirely cleared of trees is recommended. Trees that do well on light soils are box elders, jack pines, apples, plums, English filberts, etc.

Considered in its general aspects, the work which the agricultural experiment stations have done along the lines of preventing the washing and drifting of soils is of great economic significance. Means for preventing the further waste of the natural resources of the soil have been discovered. If these principles are put into practice, large tracts of land now useless can be brought under cultivation, and if these lands are worked in accordance with methods of restoring and maintaining soil fertility, which the stations and this Department have discovered and published, the extent of the wealth-producing power thus conserved to the farmers of the United States will be enormous.

POTATO BREEDING.[a]

In total value of annual production the potato crop usually ranks sixth among our field crops, standing between oats and barley. The yearly consumption of potatoes increases as the population grows, and not infrequently the annual imports exceed the annual exports. Further, in only six years since 1866 has the average yield for the whole country been over 100 bushels per acre, while ordinarily this is considered a small yield, especially by market growers. The importance of the potato crop, therefore, as well as the comparatively low average yield per acre would seem to warrant the use of improved methods to increase the annual production. In addition to employing improved cultural methods, this may be accomplished by improving the productivity of the crop.

Dr. H. J. Webber, in a recent bulletin of the New York Cornell Station, points out that even for New York State alone every means should be used to increase the production, and among other results those secured by Prof. C. W. Waid, of the Ohio Experiment Station, indicate the possibility of greatly improving the crop by tuber or bud selection. Professor Waid's work was begun in 1903, and the results obtained during three years are here summarized:

In 1904 10 hills each were planted from seed selected from 10 heavy yielding hills, and likewise 5 hills each from seed selected from 20 low-yielding hills of the crop of 1903. These 100 hills of each group were compared with 100 hills planted from seed not selected with reference to individual hills. In 1905 and 1906 this was repeated, the seed having been selected respectively from the high-yielding and low-yielding hills of the preceding year's crop. The results are briefly given in the following table:

Results with seed potatoes from high-yielding and low-yielding hills of Carman No. 3.

Source of seed.	Yield of 100 hills.				Number of tubers in 100 hills.			
	Total, 1904.	Total, 1905.	Total, 1906.	Average, 1904–6.	Total, 1904.	Total, 1905.	Total, 1906.	Average, 1904–6.
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*				
High-yielding hills	125	178	116	188	781	865	676	774
Check rows	115	186	79	110	718	680	479	[illegible]
Low-yielding hills	84	75	61	73	566	546	364	[illegible]

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[a] Compiled from New York Cornell Sta. Bul. 251; Ohio Sta. Bul. 174.

The average yield of the 100 heavy hills was 138 pounds as compared with 110 pounds for the unselected seed and 73 pounds for the seed tubers from the light-yielding hills.

As environment has a great influence on the potato, Doctor Webber advises that farmers, especially those growing potatoes extensively, determine by test the variety best suited to the locality or even to the particular farm on which the crop is produced. When the best variety available has been found a good foundation for breeding work has been laid. In fact, in plant breeding the variety or strain with which breeding work is begun is known as the foundation stock. The use of the following method is urged by Doctor Webber for carrying on the work from this point:

> (1) Examine a large number of tubers of the variety selected as the foundation stock and decide on the most desirable shape and type of tuber. In general a moderately large tuber, which is oblong or somewhat cylindrical in shape and oblong in cross section is considered most desirable. A spherical tuber if sufficiently large to be desirable is so thick that in cooking the outside is liable to become overdone before the interior is properly cooked. A tuber with shallow eyes, netted surface, and white color is also usually preferred.
>
> (2) When the ideal character and size have been determined, examine a large number of tubers and pick out a thousand or more having this size, shape, and general character. * * * These are to be used as the seed for planting the selection plat and the number selected should correspond to the size of the plat which it is desired to plant, four hills being planted with each tuber. There should certainly not be less than 1,000 and a much larger number is very desirable. The prospective breeder should remember that success in breeding work depends upon selecting the one individual that gives the very highest yield possible under the conditions, and the larger the number of individuals examined the more likely is he to discover the one producing the maximum yield which will give a valuable new strain. * * *
>
> (3) The planting should be arranged in such a way as to secure a test of the productivity of each tuber. * * * Cut each tuber into four uniform-sized pieces, making each cut longitudinally so that each piece will contain an equal proportion of the basal end and apical end of the tuber. Plant four hills with each tuber, one piece in a hill. These should be planted consecutively in each row, beginning at one end, so that starting at that end the first four hills will be from one tuber, the second four hills from another, and so on throughout the length of the row. The object in planting this way is so that the four hills can be dug together and the total product weighed to obtain a measure of the productivity of the seed tuber planted. Probably the best way to plant these is to drop the selected tubers one to each four hills and then go over the row and cut each tuber and plant its quota of four hills. The hills in the row should be planted somewhat farther apart than in ordinary planting, probably from 20 to 24 inches. If this is not done a somewhat greater distance than ordinary should be left between each 4-hill tuber unit. The writer would advise that one hill be left unplanted between each 4-hill unit. It would doubtless be convenient and desirable to have the plants in rows both ways to facilitate digging. For this selection plat of potatoes choose a field of moderately good fertility and as uniform throughout in soil as is possible to obtain.

The breeding plat is fertilized and cultivated exactly like the ordinary crop. When the vines begin to mature, but while they are yet green, the 4-hill units showing the most vigorous growth and at the same time freedom from or at least resistance to disease are selected and marked, preferably with a stake. Later each 4-hill unit which is the progeny of one tuber is dug separately and the tubers of the four hills are carefully kept together. If the particular tuber unit is marked as one of the best, the same stake may be used to mark the product. When the entire crop of the breeding plat is dug, the 50 to 100 tuber units best in yield, uniformity of product, color, shape, etc., are selected. For this work the following directions are given:

(1) Go over the field and study the tuber units in a gross way until you have well in mind the variations in yield and the general uniformity of the tubers in the various tuber units. Remember that total yield is not the only important character. What one wants is to discover those tuber units which have the largest yield of good merchantable potatoes of the best shape and appearance. Size up the field as a whole with reference to these characters.

(2) Go over each row carefully and throw out all of those tuber units which can be clearly seen to be inferior. * * * For the interest of the grower, however, it would be well to weigh the product from some of the light yielding tuber units and preserve the figures as a matter of showing the extent of variation occurring. By this first discarding process the number of tuber units will probably have been reduced to two or three hundred. It is very probable that in some cases one or more of the hills of a 4-hill tuber unit will not grow. In such cases the tuber unit will have to be judged in proportion to the number of hills actually grown.

(3) Now, provide yourself with scales of some handy pattern like the ordinary counter scales used by grocers, with which the product of each tuber unit can be easily and quickly weighed. A satisfactory scale should weigh accurately to at least a half ounce. Weigh the product of the remaining tuber units, examine the tubers more carefully as to their character and uniformity of size in the tuber unit, and select about fifty of the best units. These fifty units should naturally be from those marked as having good healthy vines in the first examination, before digging, unless all of the vines at that time were in fairly good condition. In making these final selections if some hills in a tuber unit are missing the comparative yield can be easily calculated. If one hill is missing, a comparative yield for four hills is obtained by increasing the weight from the three hills by one-third. If two hills are missing, a comparative yield for four hills would be double that obtained from the two hills. If more than two hills are missing, discard the unit entirely.

The product of the tuber units selected should then be placed in paper bags, the product of one tuber unit being placed in a bag. A good bag for the purpose is the 12-pound manila paper bag used by grocers. Number each tuber unit consecutively and place this number on the bag. In your notebook record under the number of each tuber unit the number of large, medium-sized, and small tubers, and the total weight of the product. The bags containing the seed should then be placed in suitable storage where they will not be torn and the tubers mixed. The tubers from the best discarded tuber units should be retained to plant the general crop the next year.

For the second year's planting of the breeding plat the 10 best tubers of each of the 50 select tuber units, as judged by the standard type of tuber, are selected. Each tuber unit is planted in a row by itself, and as each tuber is cut longitudinally into four equal-sized pieces, the 10 select tubers will make a row of 40 hills, and if 50 tuber units were selected the breeding plat would contain 2,000 hills. Each row receives the number of the tuber unit from which it is planted. About every tenth row may be planted with unselected seed for comparison. The selections are made the same way as the year before. At the time of digging the yield of each unit is weighed and the number of large, medium, and small tubers recorded. This record will show the tuber unit of the original selection which has given the best results. The 50 best tuber units are again selected, the tubers of each kept separately in a paper bag and each bag numbered with the number of the original tuber unit, which is also the number of the row, and with the number of the tuber unit of each row as grown in this year's plat, as follows: 1-1, 1-2, 1-3, etc., for the tuber units from the first of the 40 rows; 2-1, 2-2, 2-3, etc., for the second row, and so on to the units of the last row, numbered 40-1, 40-2, 40-3, etc. The performance record of each tuber unit should be associated with its number.

All the good tubers of the tuber units not selected should be used for planting a multiplication plat the third year, from which enough seed can be grown to plant the general crop the fourth year. The ten best tubers of each selected tuber unit are again picked out for planting the next year's breeding plat.

The third year the breeding plat is planted according to the same method just described for the second year. The multiplication plat which may be grown this year does not require any special method of cutting and planting the tubers, as any desirable method will do. In the fourth and succeeding years the work is continued along the lines laid down.

It is pointed out that as heavier-yielding strains appear all further selections should be made from these strains, and that in this way, as the work progresses, many of the original strains will be entirely discarded. As an illustration of the appearance of such strains, further results obtained by Professor Waid, as given in the table below, are presented. The figures given for 1905 and 1906 represent the average yield of original and duplicate tests.

Yields from seed selected from high-yielding hills of Carman No. 3 potatoes.

Hill No.	Yield of selected hills, 1903.		Total for 10-hill group, 1904.		Total for corresponding 10-hill group, 1905.		Total for corresponding 10-hill group, 1906.		Average 10-hill groups, 1904-6.	
	Lbs.	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*
1	2	8.0	13	12.0	16	3.0	9	4.8	13	1.3
2	2	13.0	15	4.5	15	9.0	9	.5	13	4.7
3	2	10.5	12	1.5	18	3.0	10	14.0	13	11.5
4	2	2.5	11	15.0	17	11.0	11	1.8	13	9.3
5	2	3.0	12	8.5	16	9.0	11	10.3	13	9.3
6	2	1.0	10	9.5	15	.0	14	3.3	13	4.3
7	3	1.0	13	8.5	18	7.0	15	11.0	15	14.2
8	2	7.0	10	11.5	18	1.0	13	4.3	14	.3
9	2	1.5	12	14.5	19	10.0	11	6.0	14	10.2
10	1	14.0	12	0.5	18	8.0	10	5.0	13	9.8

The table shows that hill No. 7, which had the highest yield of the original ten hills selected, in each of the three years gave a very high yield and the highest average yield for the three years.

It seems evident from these results that by the simple method of selecting seed potatoes from the most productive hills for a series of years the productiveness may be profitably increased. The farmer can hardly afford to neglect so easy and efficient a means of increasing his profits, but will undoubtedly find it to his advantage to study the practical methods most applicable to his particular conditions.

On this point Doctor Webber says:

> For many years farmers have given careful attention to the methods of seeding, cultivation, manuring, and the like, but have generally neglected to give any careful attention to the methods of seed selection or breeding. They have universally recognized the importance of stock breeding and on all dairy and stock farms more or less careful attention has been given to the matter of breeding and improvement of the strain grown. To every farmer the field of breeding, whether in plants or animals, furnishes an interesting and profitable diversion. Plant breeding especially should become a farmer's fad. Few can afford to breed animals in the extensive way necessary to secure important results, owing to the expense. No farmer, however, is so poor but that he can have his breeding patch of corn, wheat, or potatoes. Indeed, if they but knew it, they can ill afford not to have such a breeding patch to furnish seed for their own planting.

DISK-HARROWING ALFALFA.[a]

The disking of alfalfa is a common practice, and seems to be an especially effective means of destroying weeds and breaking up the silt blanket deposited in cases where muddy water is used for irrigation. The ordinary disk harrow is widely used for this purpose, but R. H. Forbes, in a bulletin of the Arizona Station, states that a special machine " for the cultivation of alfalfa has been devised on the principle of the disk harrow, but with rows of strong spikes or digging teeth in place of the continuous edges of disks. These machines are stated to be in successful operation in Australia and South Africa, and one form * * * was introduced into Arizona in 1907. * * *

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[a] Compiled from Arizona Sta. Bul. 57, p. 256; Kansas Sta. Bul. 155.

"One man with an 8-foot machine and four horses will get over 8 to 10 acres of alfalfa in a day. This work may be done in winter when teams are more at leisure; but it is probable that in summer also, after cutting and before irrigating, an occasional disking, to break up the sediment blanket, may be well worth while, especially on the upper ends of alfalfa fields."

In South Africa the necessity of disk cultivation is recognized to the extent of having contests in which prizes are given for the machine most closely meeting the requirements.[a]

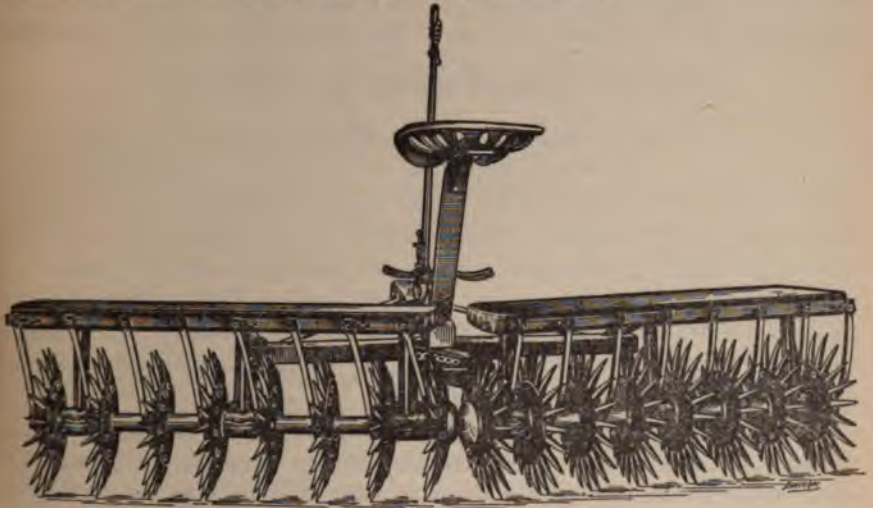

FIG. 1.—The alfalfa harrow.

A. M. Ten Eyck, of the Kansas Station, considers the cultivation of alfalfa desirable, and recommends disking in the early spring. He found "that less injury was done the alfalfa and the best work accomplished by setting the disks rather straight and weighting the harrow so as to make it cut 2 or 3 inches deep;" then cross-disking the field and harrowing it with the common straight-tooth harrow. He states that "the common disk-harrow is more generally used than any other implement to cultivate alfalfa, and when properly adjusted does good work. The spike-tooth disk, known as the 'alfalfa harrow' [fig. 1], was used on the alfalfa fields at the experiment station farm during the seasons of 1907 and 1908. This harrow does good work when properly adjusted, and is perhaps a better implement for this purpose than the common disk-harrow."

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[a] Agr. Jour. Cape Good Hope, 32 (1908), No. 4, p. 458.

The ends attained by disking alfalfa are thus concisely stated by Professor Forbes:

> At a trifling cost, varying according to individual circumstances, the disk-harrow splits and spreads the crowns of alfalfa plants, causing them to develop additional tops; it destroys the egg deposits and larvæ of certain injurious insects; it destroys weeds; it breaks up the silt blanket resulting from the use of muddy irrigating water, allowing better penetration of water and air to the roots of the crop; it loosens up certain dense soils; and to some extent it incorporates beneficial sediments and fallen alfalfa leaves with the soil.

As one of the most serious obstacles to the successful culture of alfalfa, particularly in the Eastern United States, is the crowding out of the plants in the earlier stages of growth by weeds, the introduction of implements and methods which will destroy or control the weeds is of great importance. The use of the disk harrow as described above seems to offer an efficient and practical means of securing this result.

THE MONTREAL MUSKMELON INDUSTRY.[a]

In a recent bulletin of the Vermont Station, Prof. W. Stuart states that for years a few Canadian muskmelon growers have enjoyed an almost exclusive control of the large eastern markets of the United States for their product. These growers, through carefully selected stock and skillful cultural methods, are able to produce a melon of unusual excellence over a season extending from the middle of July to frost. These melons command fancy prices ($8 to $15 per dozen wholesale), and even at such prices the Canadian growers are not able to supply the American demand.

It is quite generally believed that the Montreal muskmelons can be grown successfully only on a certain limited area on the island of Montreal. While the conditions of soil and climate may be especially favorable there, it seems reasonable to think that much of the success of the Canadian growers is due to their willingness to take infinite pains at every stage of this crop and that American farmers in the States bordering on Canada can perhaps be equally successful if they are willing to be equally painstaking.

It is recognized, however, that the crop "is an expensive and precarious one to grow, owing to frequent recurrence of unfavorable seasons and to the extreme care required to grow it successfully."

Professor Stuart states that "the cultural methods employed by Montreal growers are essentially as follows:

> The seed is sown in the greenhouse or hotbed from late February to early April; later they are potted up into 3 or 4 inch pots, and when in danger of suffering for lack of root space and plant food and the weather is favorable they are removed to sash-covered frames, there to remain until they are almost

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[a] Compiled from Vermont Sta. Rpt. 1907, p. 358; Bul. 136.

fully grown. These hotbeds are well constructed, well exposed to the sun, and also protected from cold winds. The frames are often covered with two sets of sash, mats, and board shutters. With such protection, if horse manure is used to generate a sufficient bottom heat and the exposed portions of the frame are banked therewith, the plants may be grown almost as well as in a greenhouse. These frames are movable sections approximately 12 by 6, strong and tight with tie rails for the sash to slide upon.

The soil over which these sections are set is ridged up in beds 12 to 16 feet wide with a 1-foot center elevation. A trench is dug 2 feet wide, 15 to 18 inches deep, and filled almost level with well fermenting manure, and a portion of the surface soil thrown over it, slightly more being drawn in where the plants are to be set. The frames are then set in place and covered with sash, which in turn are further reinforced with mats and wooden shutters, or hay or straw with or without the shutters. A 4 to 6 foot space is allowed between the ends of each section. When the soil over the manure is well warmed up, the warmest portion of some favorable day is selected for planting. Great care is exercised now in transferring the plants from the hotbeds to guard against setbacks from sudden changes of temperature or soil conditions. The coddling process does not cease now. It is simply spread over a greater area and the plants require even closer care than before, for greater attention must be paid to watering, syringing, and ventilation, success at this stage being very largely dependent thereon.

As the fruit attains size, it is usually lifted from the soil by a shingle or flat stone, to avoid loss from cracking, rot, etc. Uniform shape, color, netting, and ripening is secured by turning the fruit every few days. When the runners fairly occupy the inclosed area the frames are raised a few inches. As the season advances more and more air is admitted until, finally, when the melons are almost full grown, the sash and then the frames themselves are entirely removed.

As each fruit sets its shoot is pinched off one or two joints beyond it. A 15 to 20 melon crop is considered sufficient from each 6 by 12 frame. Three or four hills are planted and usually two plants are set per hill.

The melons vary greatly in size. One weighing 44 pounds has been grown. The writer saw one weighing 22 pounds, which had been selected for seed purposes. Their average weight ranges from 8 to 15 pounds, and a dozen averages from 120 to 130 pounds. In exceptional cases some have been shipped weighing 240 pounds per dozen package. The larger melons are apt to be poorer in quality than those weighing 8 to 15 pounds.

Two distinct types exist, a roundish oblate and an oblong, the first slightly deeper ribbed than the latter. These do not seem to be separated by the growers. It is not at all certain that either type is fixed.

A large wicker basket (clothes basket) is commonly employed in shipping to distant markets. They hold a dozen melons, packed in short, fine-stemmed hay, and are shipped without cover, no attempt being made to fasten the melons in place, the express company being held responsible for safe delivery.

Believing that there is no valid reason why American growers, under conditions similar to those of Montreal, should not succeed in producing these melons and that "a crop which may net $1.000 to $2,000 per acre is worth an effort to produce," the Vermont Station has undertaken experiments to determine the conditions and methods necessary to success. The first season's experiments, for various reasons which are explained, were not very successful, but Professor

Stuart states that "the knowledge secured in the handling of the crop justifies the assumption that there is no valid excuse for continuous failure on the part of American growers to produce these melons successfully."

STORAGE OF HUBBARD SQUASH.[a]

In view of the fact that the conditions controlling the losses in storage of vegetables are not very well understood, and that the advisability and profitableness of storage of vegetables for a later market depend largely upon the extent and character of such losses, Prof. W. Stuart, of the Vermont Station, undertook experiments to determine the loss of moisture and from decay sustained in storing Hubbard squash till midwinter, as well as the profitableness of such storage:

> [In these experiments a ton of squash] weighed as taken from the field, was stored on October 3 in a dry and medium warm (50° to 60° F.) room. On December 4 it weighed 1,810 pounds, a moisture loss for two months of 9.5 per cent. On January 4 it weighed 1,657 pounds (sound 1,622, decayed 35), a moisture loss of 8.5 per cent and a decay loss of 1.8 per cent. On February 3, four months from the harvest, the sound squash weighed 1,488 pounds, and the decayed 61 pounds, a moisture loss of 4.5 per cent and a decay loss of 3 per cent. The total moisture loss during four months was 20.8 per cent and that from decay 4.8 per cent; total, 25.6 per cent. * * *
>
> When the squash were put in storage they were wholesaling at 1 cent per pound, late in October at 1.5 cents, 2 cents late in December, and in January, owing to unusual scarcity, at 2.5 to 3 cents. At the conclusion of the trial the 1,488 pounds were sold for $53, an average of over 3½ cents per pound, the net gain by storage being $33 per ton. Market conditions, however, were very unusual. The common price at harvest is $15 to $20 per ton, and does not materially increase until January ($30 to $40), while during February and March they advance to $50. Hence, even under ordinary conditions the increase in price amply offsets losses from moisture, decay, and cost of storage, and leaves a handsome profit.

The conditions tending to minimize losses in storage are stated to be—

> (1) The squash should be well matured before harvest.
>
> (2) They should be cut or carefully broken from the vine, leaving the stem attached to the squash.
>
> (3) If possible, they should be placed in small piles to ripen and harden up for two or three days before hauling from the field.
>
> (4) They should be hauled in a spring wagon, the box of which is lined with burlap or other material, to prevent bruising.
>
> (5) The storage room should be dry and moderately warm at least for the first two weeks, to harden up the shells, after which a lower temperature, provided the room is dry, may be maintained.
>
> (6) Finally, squash from harvest to sale should be handled as one would handle eggs. Broken stems and bruised skin are sure to cause decay.

In general, Professor Stuart concludes that "squashes properly grown and handled may be held in storage till midwinter or later with a reasonable assurance that the moisture and decay loss will be amply covered by the increased price received."

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[a] Compiled from Vermont Sta. Rpt. 1907, p. 367; Bul. 136.

There is an additional advantage to be considered, viz, that if the squashes are stored a saving of time may be effected and the hauling to market done at a time when farm work is less urgent.

FIG CULTURE IN THE SOUTH.[a]

The fig tree has been widely though not extensively grown for many years in practically all of the Southern States. Its greatest development is in the Gulf coast region, where it was probably introduced in early times by the French and Spanish. There and along the South Atlantic coast it grows in the open without winter protection, bearing at an early age, and abundantly on soils adapted to its culture. In unusually severe winters the trees may be frozen to the ground; but if the root system has been well established, sprouts will spring up, grow rapidly, and bear in the following year. Under these conditions the tree appears as a large bush. Away from the coastal sections an annual crop is best assured by growing hardy varieties and giving some form of winter protection. The use of the bush or stool form from the start is advisable where there is frequent danger of winterkilling. W. F. Massey, of the North Carolina Station, writes as follows on the winter protection of the fig:

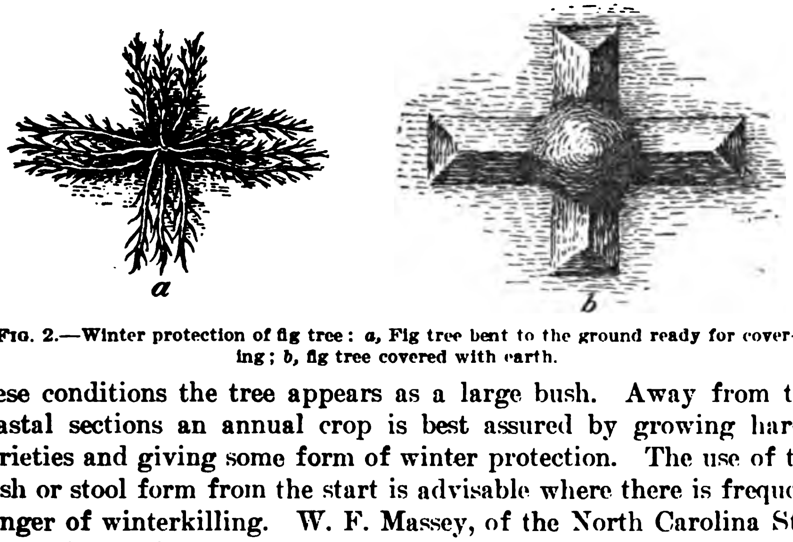

FIG. 2.—Winter protection of fig tree: *a*, Fig tree bent to the ground ready for covering; *b*, fig tree covered with earth.

> On the coast, in the immediate vicinity of salt water, it will need no winter protection. But in the cold western part of the State the method I have found successful in Maryland will do equally well. This is to branch the trees from the ground, and in fall, after the frost has cut the leaves, bend down the branches to the ground and pin them fast, and then pile the earth over them, mounding it over the center and sloping to the outside so as to throw off the water, or gather the limbs like a cross on the ground and cover each bunch separately with a higher mound in the center like a four-pointed star. [Fig. 2.] They will keep perfectly in cold climates in this way.

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[a] Compiled from Alabama College Sta. Bul. 112; Georgia Sta. Bul. 61; North Carolina Sta. Bul. 184; Tex. Sta. Bul. 62; U. S. Dept. Agr., Div. Pomol. Buls. 5, 9. See also Georgia *Sta. Bul. 77*; Louisiana Sta. Bul. 90.

He found that trees which are buried and covered with earth in the somewhat milder sections are apt to rot in the warm and rainy weather during winter.

> Here the best way possible, though very tedious and troublesome, is to thatch each limb and the stem thickly with broom sedge, wrapped on with cotton twine. This is the best protection I have ever tried; but the bending down and covering with pine boughs usually answers very well. Where the trees are to be bent down and covered, it will be necessary to plant them 20 feet apart each way, in order to give room for the covering. With the earth cover it is more certain to have good crops of figs in a cold climate than here without protection.

Relative to the use of wind-breaks, H. N. Starnes, of the Georgia Station, says:

> A good location for a fig row, on a small scale, will be found upon the south or east margin of a protecting strip of woods, though not so near the trees, of course, as to permit them to rob the figs of their own moisture and plant food. A close board fence or a building makes an excellent wind-break. In lieu of these a hedgerow of Cherokee or Macartney rose, or of Osage orange (where the latter chances to thrive) will serve. A double row of closely set Carolina poplar makes a good substitute on account of its inexpensiveness and rapid growth—for it propagates from cuttings even more readily than the fig itself and grows much faster. As it is deciduous, however, it serves only partially as a protection at the time protection is most needed. Some such evergreen material as Amoor River privet, though not so rapid in growth, is a more perfect wind-break. At the Georgia Experiment Station a row of Deodora cedar is employed for this purpose, but it requires some years to establish it, and it is not to be recommended for general use.

Even farther south, where the tree is grown as a standard and the weather is only severe during occasional winters, some form of protection is advisable for the first three years. After this period the trunk of the fig is less easily injured by cold.

That the fig has not long since been developed as a commercial fruit may be attributed chiefly to the inability thus far to produce a marketable dried fig, the fig of commerce, in the humid southern climate. Moreover, the fresh fruit, which is highly esteemed both by those who grow it and those who have acquired a taste for it, is practically unknown in large commercial centers, being an extremely poor shipper. In a previous bulletin of this Department, F. S. Earle,[a] of the Alabama Station, says, in part, relative to the shipment of fresh figs:

> Fresh figs are not known or appreciated in northern markets, and consequently the demand is too limited to encourage shipments. It seems doubtful if the distant shipment of fresh figs will ever become a profitable business. The fruit is more perishable than any other that is generally marketed. It can be handled only by the most careful and experienced persons, and even then it is not in a condition to show its best quality. Ripening in midsummer, when the northern

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[a] U. S. Dept. Agr., Div. Pomol. Bul. 5.

markets are crowded with many well-known fruits and not being especially attractive to the eye, fresh figs would at best gain favor slowly.

As a domestic fruit, however, the fig is of prime importance, for in addition to its use direct from the tree, it may be either canned or made into jams, jellies, or preserves. It is a wholesome fruit and in the older fig-growing countries is an important food. The fig should never be eaten until thoroughly ripe, since green figs contain an acrid milky juice which not only has a disagreeable flavor but is unhealthful. This trouble disappears when the fruit is ripe.

Relative to the use of the fruit for domestic purposes, Earle says:

> They are eaten fresh from the tree or are served on the table with sugar and cream. They can also be stewed and made into puddings and pies, and when canned or preserved they make an acceptable table delicacy throughout the year. * * *
>
> For canning, figs should be picked when still firm enough to hold their shape. To secure the best results they require the use of more sugar than do some other fruits. If undersweetened they seem tasteless and lacking in quality. The amount of sugar used and the method of procedure vary greatly in different households. A pound of sugar to three or four pounds of fruit would probably suit most tastes, though some prefer the regular "pound for pound" preserve. Ginger root or orange peel is sometimes added to give variety of flavoring, and figs are often made into sweet pickles by adding spices and vinegar. Figs are sometimes peeled before canning, and this is considered to increase their delicacy of flavor. More frequently, however, they are cooked unpeeled and with the stems on, just as they come from the tree. They hold their shape better and look more attractive when treated in this way, and the difference in flavor, if any, is very slight.
>
> Figs are occasionally dried for household use, but as they ripen at the South during the season of frequent summer showers, this is so troublesome that it is not often attempted. A nice product could doubtless be made by use of fruit evaporators, but these are seldom used far south.
>
> In speaking of home uses for the fig, its value as food for pigs and chickens should not be forgotten. Both are very fond of them, and on many places the waste figs form an important item of their midsummer diet. In fact, no cheaper food can be grown for them.

The future commercial development of the fig in the South probably lies in the shipment of selected fresh figs to the larger towns within 200 or 300 miles from the source of production, and in the consumption of the surplus crop and inferior grades by the canneries. Figs have been canned on a small scale for many years in lower Mississippi and Louisiana, and the industry is now being extensively developed along the Texas coast. The canned product is liked by everyone, and the present limited output is disposed of at high prices. According to recent press reports from Texas, several hundred thousand fig trees will be planted by farmers and truck growers in the coast country of that State during the coming winter. The price now paid by the canners for figs is given as $60 a ton, or an average of $150 to $200 an acre for the crop from a 4-year-old orchard.

The fig will grow in a variety of soils and is generally adapted for dooryard and garden conditions, flourishing with little care or attention. There is a scarcity of experience in the South relative to its culture under field conditions. It requires an abundance of plant food, however, and is relatively a surface feeder, the depth of the feeding roots depending to a great extent on the distance to moisture. It reaches its highest development on a fertile, moist, but well-drained loamy soil, containing an abundant supply of lime. In general, lowland soils which do not overflow, or which can be readily drained to a depth of three or more feet, will prove ideal for the fig orchard.

The trees will make satisfactory growth on fertile soils without the use of additional plant food. If either lime, phosphoric acid, or potash is lacking, it should be liberally supplied, especially when the trees reach the bearing age. Starnes, of the Georgia Station, says:

> A good annual mulch of well-rotted lot manure is the best fertilizer that can be given the fig—supplemented when the trees are of bearing age and the growth of wood is lusty and vigorous by the addition of phosphoric acid and potash. * * * Five pounds of acid phosphate and 2 pounds of muriate of potash per tree, broadcast, would not be too much. Eight pounds of kainit or a peck or so of hardwood ashes may be substituted for the muriate of potash if desired. * * * From 5 to 6 pounds per tree of air-slaked lime would prove profitable; but it should be applied separately and never in conjunction or mixed with either the lot manure or the commercial fertilizer.

On the other hand, as R. H. Price and E. A. White pointed out in a bulletin of the Texas Station, an excessive use of stable manure and other nitrogenous fertilizers should be avoided, as they stimulate a luxuriant growth of foliage and wood at the expense of the fruit.

The fig grows readily and bears early from cuttings. This is the usual method of propagation in the South. Quoting from the above-mentioned Texas bulletin:

> The cuttings are taken during the winter from wood grown the previous season. It is essential that the wood be of the right degree of maturity or the rooting process will not be successful. * * * When the wood is cut the surface of the wound should be moist and covered with small drops of milky white sap. The length of the cuttings depends upon the moisture of the soil. If the soil is quite moist they may be as short as from 4 to 8 inches, but if the surface soil be dry they must be long enough to extend down into the moisture, if it be 2 or more feet. Cuts should be made just at the joint, at both base and top. This is important, for the fig has a solid stem at the joint, but has a pith in the center of the stem between the joints which quickly decays, and the wood will always die back to the first joint. If decay once starts it is very likely to extend beyond the first joint and destroy the cuttings. * * * Insert the cuttings to the top bud in rich, moist, well-drained land. It is essential that the soil be well packed at the base of the cutting, for if an air space be left the cutting will likely shrivel without rooting.

Where the climate is too severe to plant the cuttings immediately in the open, they may be bundled and buried until spring, as with ape cuttings. It is frequently advised that the cuttings be planted the site the tree is to occupy permanently, as the fig is often severely back by transplanting. When transplanted to the orchard from e nursery row the roots should be carefully protected from drying t. It is well to plant two or more cuttings in each tree position. is will tend to lessen vacancies in the orchard, and the excess num- r can be taken out later. Planting distances differ with the vari- es grown, and with varying soil and climatic conditions. Avail- le figures indicate that 12 by 16 feet, with every other row removed en the trees begin to crowd, will be sufficient for most varieties. is would leave the permanent planting 16 by 24 feet.

No general system of orchard cultivation has been worked out for fig in the South. Some advocate as little culture as possible, ce the fig is a shallow feeder. If the preparatory plowing as well subsequent cultivations are made as deep as is consistent with the ture of the soil in each case, the roots will be encouraged to feed ore deeply and the danger from mechanical injury confined largely thin soils.

On the thin soils which abound in many parts of the Southeast it difficult to cultivate without doing serious injury to the roots. arle suggests "mulching heavily near the tree with any available aterial that will hold moisture and keep down the weeds. * * * he middle of the rows can be kept clean by a shallow plowing and rrowing without disturbing the mulch and without injury to the ots protected by it." When the weeds and grass are not allowed get too big a start, the small-toothed cultivator or an acme harrow ll prove efficient tools for surface culture. The practice at the xas Station, where the soil is a heavy clay loam, has been "to sk the orchard lightly at frequent intervals during the spring and rly summer to keep down the weeds and conserve the moisture." is method proved satisfactory for tree growth.

Frequent pruning is considered detrimental to the fig tree. The ality of the fruit is not improved and the quantity is usually de- eased thereby. The general advice is given to prune only suffi- ntly to shape the young tree, to remove all injured wood, and to in out the head of the tree to admit air and sunlight. All cuts ould be made at a joint, and as a rule the branches or canes should completely removed, rather than stubbed back. When a branch only partially removed, the numerous shoots forming below the ut make the head irregular in shape and necessitate more pruning ter on. Where the fig is to be grown as a standard tree, pinching ack the leader during the growing season will hasten the develop- ent of the lateral branches. The use of low branching standards shade the soil is advisable in sections where long-continued droughts occur. The same effect may be produced by starting two or three main stems from the ground. The latter form of tree is less liable to break down under a heavy crop. In colder sections, where the bush or stool form is grown, pruning should be limited chiefly to the removal of weak or injured canes.

The Celeste, Brown Turkey, and Brunswick appear to be the three most widely grown general-purpose varieties. The prospective grower, however, will be assisted in the choice of varieties for different purposes and sections by consulting "Varieties of Fruits Recommended for Planting."[a] He should also seek the advice of the State experiment stations and of local practical growers, since varietal names are not the same in all sections and, furthermore, well-known varieties are held in different esteem in different sections. The Celestial or Celeste is preferred for canning in the northern Gulf coast region, while a variety locally known as the Magnolia but said to be identical with the Brunswick grown at the Texas Station, is largely used for canning in the coast region of that State.

The fig has thus far been relatively free from insect pests and fungus diseases in the South. Relative to maladies in Georgia, Starnes writes, "its worst enemies appear to be wet weather and fruit depredators such as birds, junebugs, wasps, and other insects." The birds, he says, "pay their score most royally by the destruction they visit upon insects injurious to other crops. * * * Fungus affections are fortunately few and do not affect a great amount of damage, if we except the operation of the ferment producing the fig 'sour,' which is almost always a concomitant of prolonged wet weather. A leaf rust sometimes prematurely defoliates the trees, but does not do much harm." Although the cotton root-rot fungus (*Ozonium auricomum*) is said to occur on the fig, no particular damage from this source has been thus far reported.

The nematode *Heterodera radicicola*, a minute worm which causes the disease known as root knot by infesting the soft fibrous roots, thrives best in moist sandy soils, and is more or less troublesome throughout the entire coast region. Starnes advises the use of the mattock as the best remedy for this trouble. "Figs develop so rapidly that a vacancy is soon filled, and the chance of the malady, whatever it may be, involving the rest of the plat, is thereby reduced. Yet it is well to be first assured that some actively injurious agency and not deficient nourishment is the operating cause. Therefore on noting any apparent weakness or deterioration the sickly individual should receive a top-dressing of nitrate of soda. If this fails to renew its vigor and the tree still maintains an abnormal appearance, grub it out and renew."

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[a] U. S. Dept. Agr., Farmers' Bul. 208.

The remedy advised by J. C. Neal in a previous bulletin of this Department,[a] which consists of draining the land thoroughly and applying tobacco dust mixed with unleached ashes or lime, is reported as having been tried with success in some sections of the Texas coast country. The orchard should be planted on land known to be free from the pest, and truck crops should not be grown between the rows, as they are nearly all subject to root knot.

The fig-tree borer (*Ptychodes vittatus*) has caused some trouble in certain parts of Louisiana and Mississippi. Of this pest W. C. Stubbs, of the Louisiana Stations, says:

> The damage done in Louisiana is to a large extent conjectural. In our groves we have lost several trees temporarily, all being bored into by this borer. They, however, start up again quickly from the roots and soon replace the injured trees. We have had no remedy against this invasion except to dig it out while very young with a penknife. We have tried various insecticides without apparent results.

During long-continued rainy weather or in wet soils the crop often sours on the tree. Aside from attention to drainage and using care not to overirrigate, little can be done for this trouble.

The fig should be thoroughly ripe when picked for immediate home consumption, and only a trifle green when picked for shipment. Quoting from a bulletin of the Georgia Station—

> It must be picked fully ripe to be worth eating and can not be gathered prematurely, like the peach or plum. But a day's wilt somewhat improves its quality and increases the sugar content, provided it is carefully handled. After twenty-four hours, however, the danger line is reached and fermentation is imminent. It must therefore be handled rapidly as well as tenderly. * * *
>
> Gathering the fig is a difficult and clumsy process when the fruit can not be reached by hand from the ground, on account of its very soft character. It is almost as troublesome to gather safely as is the persimmon, and the slightest fall ruins it. * * * Yet the fig tree, while possessing brittle wood, and therefore not to be climbed, is fortunately not lofty, as a rule, and its fruit is readily reached by the help of a stepladder. From the ground the fruit may be conveniently reached by means of a home-made "gatherer" or "fig cup," constructed very simply by tacking a baking-powder can to a pole of any desired length, first filing a portion of the rim of the can to a cutting edge. For horizontal work—reaching out from the ladder for distant fruit—a modification may be made by tacking the can to a pole at a right angle to it, like a dip net.
>
> Shipping must be effected in either berry cups or extremely shallow trays—preferably the former. The standard 24-quart strawberry crate is the best package to use. Only nearby markets are practicable.

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[a] U. S. Dept. Agr., Div. Ent. Bul. 20.

Sufficient has been said in this article to indicate in a general way the possibilities and cultural requirements of the fig for the South. It should be borne in mind, however, that there are as yet no extensive fig orchards in that region and that every such planting will be, to a large extent, an experiment in which the individual planter must work out questions pertaining to soil, climate, and varieties as well as many of the details of cultivation. In general it may be said that, other conditions being equal, the farther South the fig is grown the greater will be the chance of success.

PURE CULTURES IN MUSHROOM GROWING.[a]

As pointed out in a previous Farmers' Bulletin,[b] the use of pure or tissue cultures for mushrooms has developed as a result of investigations of this Department. There are now several commercial kinds of these cultures. The use of pure cultures in this case, as in case of butter making, cheese making, and other processes, results in greater uniformity and certainty of the product.

F. A. Waugh, of the Massachusetts Station, compared pure-culture spawn with English and French spawn in mushroom culture during two years under ordinary conditions and found that pure-culture spawn is, as a rule, very much better than either English or French spawn, but that there are important points of difference between the commercial pure-culture varieties. These differences consist in color, flavor, form, and, above all else, in productivity.

In all of the experiments pure cultures gave larger yields than either the English or French spawn.

" It seems to be one of the chief advantages of the new method of growing mushroom spawn from pure culture that it nearly always gives fresher and more vigorous spawn. The product is nearly always more uniform and of higher quality; but, while this advantage is important, it is not so great as the one already mentioned."

As a general result of his experience in mushroom culture, Professor Waugh expresses the opinion " that mushrooms can often be grown profitably as a catch crop in cellars or under greenhouse benches where conditions are favorable. The most important favorable condition to be considered is a cheap and reliable supply of fresh horse manure. It is quite plain, however, from our experience, that the stories of sudden wealth accumulating from mushroom growing are mostly fictitious."

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[a] Compiled from Massachusetts Sta. Rpt. 1906, p. 208.

[b] U. S. Dept. Agr., Farmers' Bul. 204.

PRESERVING WILD MUSHROOMS.[a]

In a bulletin of the Oregon Station, E. F. Pernot urges that "while the growing of mushrooms is an easy matter, requiring but little time and attention, we must not neglect to utilize the abundance which grow wild, requiring only the effort of gathering and preserving them for future use." He states that mushrooms "may be canned as easily as fruit and much easier than some vegetables."

The buttons ranging in size from the smallest to those with the cup breaking from the stem are the most desirable for canning, as they remain firm and white after being heated. When sufficient buttons are gathered they are cleaned by peeling, or by wiping with a cloth, removing any soiled spots or earth which may have adhered to them; the stems are cut off, leaving from one-half to 1 inch remaining attached to the cap. They may then be placed in a granite-iron kettle and heated without water until shrinkage ceases, after which they are placed in cans that have previously been cleaned and scalded, and the liquor poured over them, completely filling the can.

If glass cans are used, after filling they are placed in any kind of vessel provided with a cover and containing a small amount of hot water. A sheet of asbestos or a thin layer of excelsior is placed in the boiler to prevent the glass coming in contact with the bottom. The caps are placed loosely on the cans and with steamer cover in place allow the water to simmer for half an hour. Upon removing the cover from the steamer, immediately screw the can covers down as tightly as possible, then place the cans away to cool, upside down, in order to detect any leak. If all are perfectly sealed, allow them to stand until the next day at the same time, when they are again heated in the same manner, except that the time must be prolonged to one hour, because the contents of the cans are cold. Repeat this operation again the third day, which will complete the sterilization, and the mushrooms will be found to be as nearly like the fresh article as it is possible to have them. They keep well and do not deteriorate in consistency nor flavor. The cans must be kept sealed throughout the operation.

If desired the mushrooms may be stewed in milk, or prepared in any manner for the table and then canned in the manner described. When the can is opened they require heating only before serving.

When tin cans are used they are handled in the same manner as the glass ones, with the exception of soldering the lid as soon as the can is filled, leaving the vent open until after heating the first time, when it is immediately closed with a drop of solder while can is hot, thus forming a partial vacuum that takes up the expansion caused by subsequent heatings.

This method of sterilizing kills the vegetative germ cell at the first heating, and the intermission between heatings induces the spores to germinate into cells, thus enabling a much lower temperature to be used than what would be required to kill the spores.

If it is desirable to sterilize the mushrooms at one operation, the cans should be filled as already described and, after sealing, heated to a temperature of 240° F. for thirty minutes. This, however, requires a steam chest capable of withstanding a pressure of over 15 pounds to the square inch and is not commonly found in the home; besides the flavor and texture of the article being canned is materially impaired by this high temperature, and glass cans can not be used.

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[a] Compiled from Oregon Sta. Bul. 98.

When the older mushrooms are used for canning they reduce very much in bulk, becoming mushy and turn black after being heated. They do not present such a tempting appearance, but the flavor is not impaired.

A good use to make of the older mushrooms is to dry them. This may be done after they have been peeled or cleaned by placing them upon boards, or drying racks, only one deep, and exposing them to the sun and air. Beginning with the cap side down they should be turned over every day and must not be left out during the night, as they absorb moisture very rapidly. They may also be dried upon wooden trays in a warm room. When dried by either method until they feel dry to the touch, finish them in the oven and while brittle grind them into a fine powder with a spice mill, or even a coffee mill will answer the purpose. The powder should at once be placed into well-stoppered, dry bottles or fruit jars well sealed and kept in a warm, dry place. Mushrooms that are wet can not be successfully dried. The best are those which grow and are gathered dry.

Mushroom powder keeps very well and it is one of the most delicious flavoring condiments of the kitchen. If milk is used in making meat gravy or other dishes, the flavor is much more pronounced.

The mushrooms may also be dried in the manner described and used whole by first soaking them before preparing the various dishes; they are practically the same as fresh ones with the exception of being somewhat tough. The flavor is fully as strong as in fresh ones.

Mushrooms in various stages of development will be secured at each gathering, but these may all be utilized. "The buttons of various sizes may be canned, those with caps fully opened and firm may be dried and used whole or made into powder, while the older ones, those which have been broken, and stems, are made into catsup."

The author recommends the following recipe for making catsup as one which preserves the flavor and keeps well after the bottles are opened:

Take all the mushrooms that can not be used for canning and drying, or all good ones, if desired, place them in an earthen jar and sprinkle salt over them, stirring so that all receive the salt; allow them to stand for twelve hours; then mash and strain through a cloth. For every quart of the liquid add one-half teaspoonful ground ginger and one-half teaspoonful black pepper. Boil in a granite iron kettle until it is reduced not less than one-third. Prepare the bottles by cleaning and thoroughly boiling them and their corks, then fill to the neck with hot catsup, cork tightly and when the cork has dried and before they are cold, dip the cork and about half an inch of the bottle neck into hot canning wax, previously melted in a cup or can. It is advisable to use rather small-sized bottles so that the contents may be used before remaining open too long.

Attention is called to the fact that in "some seasons, and under certain weather conditions, mushrooms are infested with insect larvæ, unfitting them for use in any form. They are most always found where the cap joins the stem and can easily be seen by breaking off the stem where they are localized at that point. In later stages they will be found to infest the cap and stem. The buttons are less likely to have them than the more mature fungus."

The variety of mushroom referred to in the above directions is the common pink-gilled field mushroom (*Agaricus campestris*). This variety the author states " may readily be recognized by a child without fear of obtaining a poisonous one."

> It first appears in the form of a white ball, or button, connected by a stem which extends into the earth; as it increases in size the cap expands from the lower side and a veil which connects it with the stem is torn, leaving a ragged membrane adhering to the stem. The cap is covered with a rather tough skin which may be peeled off quite readily. The gills vary in color from a delicate pink in the young growth, to a deep brown as they mature; they are not attached to the stem. The stem is white, smooth, and brittle, with the lower end somewhat pointed and blunt. When young it is as good to eat as the cap. No mushrooms having a bulb or cup on the lower end of the stem should be eaten.

The food value of mushrooms has been discussed in a previous bulletin of this series.[a]

COOKING BEANS AND OTHER VEGETABLES.[b]

In connection with the home economics work at the Ontario Agricultural College, Miss M. U. Watson reports the results of tests in cooking dried beans and vegetables.

Beans.—Four samples of beans, each lot weighing 8 ounces, were soaked in lime water containing 0.03 per cent lime, in hard water from the local supply, in the same water softened by boiling and also by the use of bicarbonate of soda, in the proportion of 1 teaspoonful to a gallon, the work being undertaken with a view to ascertaining the effects of hard and soft water upon the quantity of cooked beans. After twelve hours the samples soaked in softened water each weighed 12.75 ounces, those soaked in lime water and hard water 12.25 and 12.5 ounces, respectively, and it was found that the smallest amount of material, 1.8 grams in round numbers, had been removed from the beans soaked in water softened by boiling, and the largest amount, 2.5 grams, in the beans soaked in water softened with bicarbonate of soda.

Each lot of beans was then cooked for three hours in a double boiler and showed some differences in quality and appearance. The smallest amount of protein removed, 3.6 grams, was noted with the beans which had been soaked in water softened by boiling, and the largest amount, 5.4 grams, in those which had been soaked in water containing bicarbonate of soda.

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[a] U. S. Dept. Agr., Farmers' Bul. 79, p. 18.

[b] Compiled from Ann. Rpt. Ontario Agr. Col. and Expt. Farm, 33 (1907), p. 240.

In general, the beans soaked in softened water absorbed more water than the others and consequently increased more in weight. Three hours' cooking at the simmering point did not soften and disintegrate the cellulose of beans cooked in hard water, and such beans the author considers neither palatable nor digestible.

The harder the water in which beans are cooked for a given length of time, the more unpalatable and indigestible the beans, and the more protein lost in cooking.

Beans cooked in water softened by boiling have, the author states, a much more appetizing appearance than those cooked in water softened by baking soda. They keep their shape better and are only very slightly colored yellow. They are also more mealy and "would therefore be most digestible, as the saliva could most easily mix with the particles of the bean."

The author therefore considers that the beans cooked in water softened by boiling were the most palatable and nutritious, while at the same time they lost least of their nutritive constituents in soaking and cooking.

"As seen in this experiment, the best results are obtained by cooking beans in water softened by boiling."

Strong-smelling vegetables.—In tests which were undertaken to learn the best methods of cooking strong-smelling vegetables to secure a palatable product and to avoid odors in the house, half-pound samples of cabbage and onions were cooked in salted and unsalted water in covered and uncovered pots. It was found that when the vegetables were cooked by simmering in a close-covered pot less steam was formed than when they were boiled vigorously, and of this steam little escaped into the room, and consequently there was less odor noticeable than under the other experimental conditions. Vegetables cooked by simmering in a covered pot had also a much better color than the others. The best results were obtained when salt was added before cooking. If added afterwards the flavor was more insipid. More substance was dissolved out when salt water was used, but as the author notes, " we do not depend on cabbage or onions to give us food substance, so the little loss is not of much importance."

The general conclusion reached is that " the best method of cooking strong-smelling vegetables is to simmer in a covered pot in salted

A MODEL KITCHEN.[a]

At a housekeepers' conference held at the Agricultural College of the University of Missouri, the experiment station exhibited a full-sized model of a convenient farm kitchen. As pointed out by Dr. Edna D. Day, of the home economics department, in her account is project, it is essential that the necessary routine work of the e should be made easy if the home maker is to have time, energy, enthusiasm for her home life, and there is perhaps no place in ome where more unnecessary time and energy are expended than e ordinary kitchen, owing to faulty planning and inconvenient truction and furnishing. In this model kitchen an effort has been e to secure economy in steps taken and in the time and energy ired for housework. The diagram (fig. 3) shows the general plan e kitchen, its position in relation to the pantry, dining room, and r rooms, and the location of the range and other kitchen furniture.

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[a] Compiled from Missouri Sta. Cir. Inform. 30.

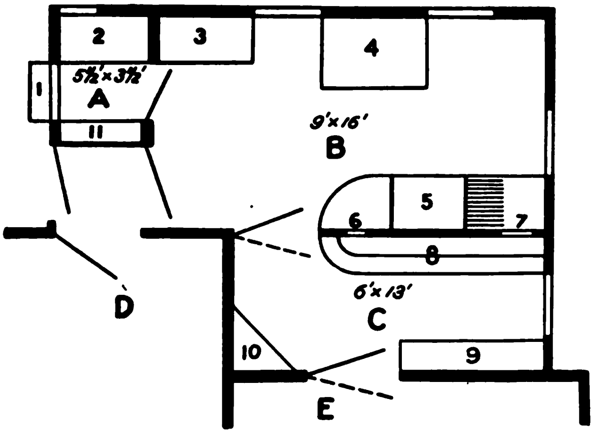

FIG. 3.—Plan of a model kitchen (scale: ⅛ in. is 1 ft.): A, Cold pantry; B, kitchen; C, butler's pantry; D, back hall; E, dining room. 1. Window box to be used to keep food material in cold weather. 2. Refrigerator with outside door for icing. 3. Kitchen cabinet. 4. Range. 5. Sink with shelves and draining board on either side. 6. Door for passage of soiled dishes from pantry into kitchen. 7. Door for clean dishes to be passed back. 8. Shelves in pantry. 9 and 10. Shelves with glass doors. 11. Shelves in cold pantry.

floor covering of oilcloth or linoleum is suggested as desirable, it can be kept an easily by ping, and it not require l and knee rk with a bbing brush. best wear the re expensive is preferable, even a cheap r covering, ch needs very uent replac- is, in Miss y's opinion, erable to a d flooring, ch needs more bbing. "An l hard-wood r is easily ned, but dark and unattractive. Tiling is clean, but harder for feet than linoleum." A sanitary wall covering in imitation of g is recommended, which is applied like ordinary wall paper, which is comparatively cheap, easily cleaned, and attractive. It t be carefully hung so that there may be no cracks or other hiding es for vermin. Metal tiling is perhaps more sanitary, but is also e expensive. It is, however, cheaper than true tiling and perhaps tisfactory.

this model kitchen a model kitchen cabinet, which provides y conveniences and has the advantage of grouping working erials at hand where they are needed, is placed where there is good light, next to the stove, on the one hand, and to the cold pantry, on the other, with the sink at the back. The stove is also placed where light is abundant.

The easily cleaned refrigerator, in the conveniently placed cold pantry, has an ice door that can be reached from the outside, saving the kitchen floor the dripping and footprints which generally mark the iceman's path. Outside of the pantry window is a box in which food can be kept cold many months in the year without the use of ice. If well finished and painted the color of the house on the outside, this need not mar the exterior appearance of the house. The shelves in the pantry afford room for storing food materials.

The small table on rollers can be moved into the cold pantry for pastry work when the kitchen is too hot. It can conveniently find place between the kitchen cabinet and stove when frying or other cooking makes a table at that point convenient. In kitchens where sink and china closet are far apart, such a table saves many steps at dish-washing time. In this kitchen the lowest shelf of the china pantry is convenient for the reception of dirty dishes from the dining-room table. Here they can be scraped and piled and passed through the window on to the shelf at the right of the sink.

A window at the end of the drain board gives light for the dish washing and allows, if the view be good, a chance for inspiration during the mechanical work of dish wiping. The window into the cupboard over the drain board may be made small, allowing simply for the passage inward of the piles of clean dishes, or may be made large enough to give access to the back of all the shelves in that part of the pantry, allowing each dish to go directly from the dish towel to its place on the pantry shelf. The opening may be closed with glass or wooden doors.

At the farther end of the kitchen is a place for the ironing board near to both stove and windows, but entirely out of the way of other workers in the room. It may be hinged to the wall at one end and folded up into a wall cabinet when not in use. Inclosed shelves below may give place for the irons, holders, and wax. The heights of the ironing board, sink, and table should be suitable to the height of the worker. A high stool can be used to advantage at the sink and kitchen cabinet. Every kitchen should have at least one comfortable chair. Since at best many hours daily must be spent in the kitchen, its arrangements and equipments should be such as to make the work there as easy and as attractive as possible.

Some of the visitors said that the kitchen was too small for a farm, but those who had had experience both in a small, conveniently arranged kitchen and in a large one in which miles must be walked in doing the ordinary day's work, were in favor of the compact arrangement.

LA… …ARY
SAN FRANCISCO

Issued January 20, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 343.

THE CULTIVATION OF TOBACCO IN KENTUCKY AND TENNESSEE.

BY

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Collaborator,

AND

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., November 5, 1908.

Sir: I have the honor to transmit herewith a paper entitled "The Cultivation of Tobacco in Kentucky and Tennessee," by Messrs. W. H. Scherffius, Collaborator, and H. Woosley and C. A. Mahan, Special Agents, Tobacco Investigations. I recommend that this manuscript be published as a Farmers' Bulletin.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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HE CULTIVATION OF TOBACCO IN KENTUCKY AND TENNESSEE.

INTRODUCTION.

obacco belongs to the order of plants commonly known as the htshade family. Its generic name, "Nicotiana," was given to it honor of Jean Nicot, French ambassador to Portugal in 1660. en, two years before this, specimens of tobacco had been brought m Mexico to Spain, Nicot secured some of the seeds and sent them Paris.

here are fifty or more species of the genus Nicotiana, though few hem enter into the commerce of the world. The species grown in Ohio Valley, the one of chief importance, is *Nicotiana tabacum.* aborigines of America grew tobacco long before the advent of white man. The French explorers Marquette and La Salle found n cultivation and use by the Indians along the Mississippi and io rivers and their tributaries as early as 1669 and 1673. In 0, nearly one hundred years later, Capt. Christopher Gist, an nt for the "Ohio Company," came down the Ohio River and nd tobacco being grown by a tribe of Indians at Shawneestown, present site of Portsmouth, Ohio. During this same time tobacco s being grown by the Shawnees at the present site of Indian Fields, ., in Clark County.

n 1775 white pioneers migrating westward from Virginia and rth Carolina made a permanent settlement at Boonsboro, Ky. ing familiar with the handling of tobacco and its value, they nediately began growing it along with other crops. Soon after founding of Boonsboro the price of tobacco increased rapidly, ich encouraged the tobacco farmers of Virginia and North rolina to migrate into this new and fertile territory. As early 1792, when Kentucky was admitted into the Union, settlements e being established throughout the States bordering on the Ohio er. Following the custom in Virginia, tobacco became a medium exchange. After home consumption had been supplied the sur- s was shipped down the Mississippi to New Orleans for exportation. The French settlers of the Illinois country had there been following this method of disposing of their surplus for nearly a quarter of a century. As the population increased, the demands of the home market likewise increased, and in a short while establishments were located at Lexington, Ky., and other points for the purpose of manufacturing plug and twist tobaccos for home consumption. A steadily increasing demand on the home market developed, while the export business dwindled to nothing and was not revived until after the close of the civil war.

In 1866 a very important discovery pertaining to tobacco was made by Mr. George Webb, a farmer living in Brown County, Ohio. He noticed in his field of tobacco some plants which were light green in color, with cream-colored midribs and stalks. The seed which had produced this type was furnished to Mr. Webb by the United States Commissioner of Patents, in whose office at that time the distribution of seeds under Government auspices was conducted, and these plants were probably mutations, or sports, due to the effect of change in soil or climatic conditions. They were so different in appearance from those which produced red tobacco that Mr. Webb carefully preserved them and saved the seed. It was noticed that tobacco from this selection of seed gave a brighter cured product than the original red tobacco from which it was obtained. The new type of tobacco gained favor rapidly on account of its mild quality and bright silky appearance, and its cultivation soon spread over what is known as the White Burley district. This type now supplies the market with chewing, cigarette, pipe, and cigar tobaccos, but the greater part of it is manufactured into chewing tobacco.

The dark-tobacco district, including western Kentucky, part of western Tennessee, a small area of Missouri, southern Illinois, and southwestern Indiana, produces a dark, heavy type, which is principally exported to European countries.

In view of the fact that Kentucky and the bordering States produce 376,647,000 pounds annually—one-sixth of the total production of the world, and more than one-half of the production of the entire United States—of a quality of tobacco which is peculiarly confined on account of soil and climatic conditions to this area, we may expect that a great part of the world will continue to look to this western section for supplies for its consumption.

Much has been written in recent years in regard to the improvement of the tobacco plant by breeding and seed selection, but littl reference has been made to the actual field operations employed in th cultivation of the crop in this western section. It is the object of thi bulletin to present the best methods of cultivation now in use, wit [illegible]tailed descriptions of the principal operations employed.

THE PLANT BED FOR TOBACCO.

plant bed should be located on some well-drained spot, with
rn and eastern exposure if possible. This gives the maximum
it of sunshine and a protection against the cold northern and
n winds. It is a common practice to select a place in the woods
the soil is loose, friable, and rich in humus, but in sections
wooded tracts are scarce plots covered with brier patches or
y growth of shrubbery often found in abandoned fields make
le locations. A good substitute for virgin soil and one often
the White Burley district is a field bearing a heavy growth of
ss sod, but cultivated lands do not give as good results and
not be used if it can be avoided. A few successful farmers
same bed for several consecutive years. In such cases an
tion of barnyard manure and tobacco stems or stalks should
e in the fall. During the winter the soluble elements are re-
by leaching and carried into the soil. When the time for
has arrived, the manure and stems are raked off and heaps of
ood and brush are piled on the bed and burned.

e the barnyard manure and tobacco stems or stalks have not
viously applied, an application of high-grade commercial fer
ne containing, say, 10 per cent of potash, 4 per cent of nitro
10 per cent of phosphoric acid, all in an available form, [illegible]
d results. It should be applied at the rate of [illegible] pounds for
500 square yards. Commercial fertilizers are not [illegible]
The farmers as a rule depend entirely upon the [illegible]
the soil to produce the desired growth in the young [illegible]
transplanting.

preparation of the seed bed is of [illegible]
or labor should be spared in making [illegible]
Neglect to have plenty of good plants [illegible]
of a crop and may result in [illegible]
e main object in burning the [illegible]
destruction of weed seeds [illegible]
terfere with the growth [illegible]
s are lodged in the upper [illegible]
eadily destroyed by burning [illegible]
nt foods, such as potash [illegible]
rning, which adds [illegible]
her hand, organic matter [illegible]
s detrimental to the extent [illegible]
hus reducing the amount [illegible]
he moisture-holding capacity [illegible]
umus.

The scarcity of wood has caused the advent of a tobacco bed bu which is a movable device especially designed for burning plant l The furnace is 3 feet wide and 9 feet long and is arranged wi pan on which the soil is placed and roasted for about an hour. fire is fed under one end, similar to the way an evaporating pa heated in making molasses. A block of soil 9 feet long, 3 feet v and 2 inches deep alongside of the furnace is shoveled into the per. During the heating it should be turned over two or three t with a long-handled shovel. The roasted soil is then shoveled ou the hopper back into the hole from which it was taken. This operation is repeated with the soil on the other side of the furn By the time this second block of soil is roasted the soil covered by furnace is likewise sufficiently heated. Hence, at each setting, a s

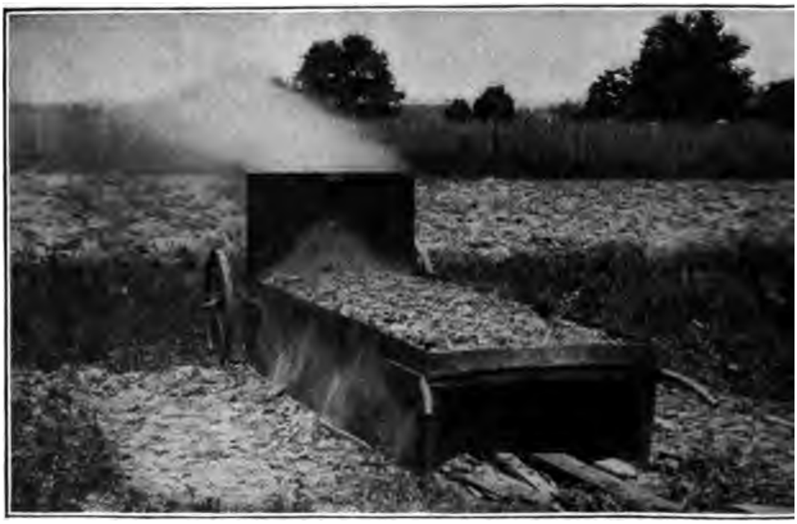


FIG. 1.—Tobacco bed burner in operation.

of 9 feet by 9 feet is burned. Reference to the illustration (fig will give a good idea of how the furnace is constructed.

Under ordinary circumstances, 45 to 50 square yards of gro can be burned with this furnace in a day. If a stiff wet clay is be dealt with, more time will be consumed in burning and the area c ered in a day will be correspondingly lessened. The principal vantages of the furnace are that the ground can be burned while without fear of baking except in the area directly beneath the f nace, a more uniform and thorough burning may be secured, mo weed seeds are destroyed, and less wood is required. The furnace made of sheet iron throughout, costs about $35, and is serviceable f several years. This type of furnace has been in use for four or fi years, but has not come into use by a majority of the farmers.

'he bed may be burned at any time from November to the last of rch. A few farmers burn in the fall, a desirable practice in many ects. The weed seeds are then on top of the ground and the is likely to contain less moisture, so that much less fuel is re- red. Most beds are burned by the open-fire method during Febru- and March, as weather conditions are favorable at that time. It referable to have the soil as dry as possible in order to avoid ing in burning and to economize time and fuel. If much water to be evaporated from the soil unnecessary delay is experienced. few farmers sterilize their beds with steam.[a] In this case a steam of the desired dimensions is constructed and placed over the cted spot, a boiler for supplying the steam being used. Suffi- it pressure to destroy all weed seeds can be easily maintained. ginning with 120 pounds of steam it will be reduced to about 90 nds in a single operation. While this method of sterilizing has come into general use, those who have tried it pronounce it a com- e success. After the bed is sterilized it is thoroughly worked depth of from 2 to 4 inches with hoes, rakes, and disk plows arrows.

t is a common practice to raise the level of the bed a little above surrounding surface by bedding; also to leave 12-inch valleys und the bed and have them cross the bed at intervals of from 12 feet. This gives good surface drainage. After the soil is thoroughly prepared, the seed is sown; in the Burley district at rate of 1 teaspoonful to every 200 square feet; in the dark dis at the rate of 1 teaspoonful to every 300 square feet. There i good reason for this difference; custom has established these meas

---

[a] The method of steam sterilization of tobacco seed beds in the Connecticut ey, devised by Mr. A. D. Shamel, of the Bureau of Plant Industry, and now ractical and successful use in that region, is as follows: A steam pan is e of sheet iron, 10 feet long, 6 feet wide, and 6 inches deep. Attachments made which provide for the introduction of steam into this pan and for the ection of the steam hose or pipe running from the steam boiler to the pan. steam hose should be at least 1 inch in diameter and 50 feet long, so as to nit the supply of an abundance of steam and in order that the box may be ed without moving the steam boiler.

he soil for the seed bed is fertilized and prepared in the same manner as for sowing of the seed. The pan is turned over a section of this prepared soil care taken that the edges of the pan sink into the loose soil, so as to pre- the loss of steam under the edges of the pan.

he steam is now turned into the pan, and on being confined under the pan er pressure it rapidly heats the soil to the desired depth. A strong pressure ld be maintained in the steam boiler and a full supply turned into the pan. the beginning the temperature of the heated soil should be frequently rmined. It is desirable to heat the soil to 175° F. to a depth of at least 4 es and to maintain this temperature for about one hour. This treatment roys the weed seeds and diseases in this soil and improves the condition of seed-bed soil for the growth of tobacco seedlings.

bout 600 square feet of seed-bed surface can be treated in one day according his plan. The tobacco seed should be sowed the following day and lightly d in.

In view of the fact that the seeds are so small, a sufficient q tity to sow a bed is mixed with one-half gallon of fertilizer, ashes, or corn meal, so that the sower may secure a more even distrib of them. They may be settled into the ground by rolling, tramp or lightly raking over the bed.

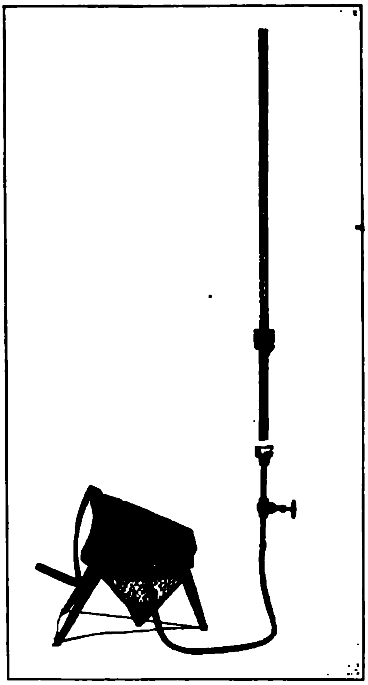


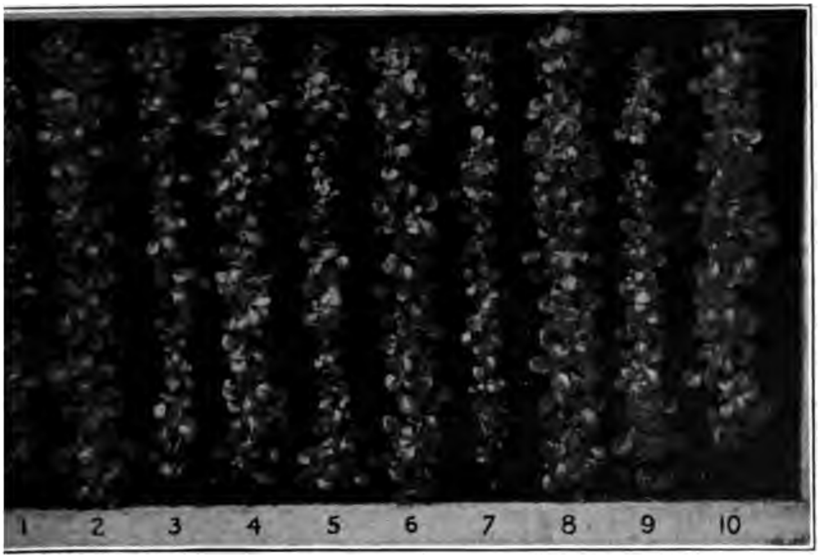
FIG. 2. Tobacco seed grader for separating heavy from light seed, devised by Mr. A. D. Shamel, of the Bureau of Plant Industry.

During the winter months b sowing time the seed shoul graded in a tobacco seed sepa like that shown in figure 2, w will remove all the light and i ture seeds. The importance of seed in every crop has been de strated so often that every fa should know that it pays him w sow only the best. It has been onstrated here and elsewhere the lack of uniformity in our tol fields is largely due to poor (See fig. 3.)

Sowing should not be made than April 1. Beds sown from uary to April produce plants setting by May 15 to June 10, w is usually the best time. If weather conditions are such sowing can not take place until the seeds can be partly germin by mixing the quantity to be s with sand about ten days prev to sowing. The sand should be l moistened and in a warm place. If the mixture is kept in a favorable situation, it is not desirable to extend the soaking pe more than ten days. The tobacco seed coat is comparatively thick hard to break, however, and usually three weeks are required be complete germination takes place.

CARE OF THE BED.

To secure rapid growth of the young plants and to afford pro tion from frosts it is necessary to use a covering, which is usu made of ordinary cheese cloth. The bed is boxed up by using 1-i ls placed on edge, extending all around the bed. Wires are hed across or pegs or wickets are put down a few feet apart on ed and arranged to hold the canvas a few inches from the ground. widths of canvas are sewed together to fit the bed, and are



3.—Tobacco plants in germinating box. Those from heavy seed are indicated by even numbers; those from light seed, by odd numbers.

tched over the bed and tacked to the surrounding plank (fig. 4). y open spaces that may occur under the boards are filled by king the earth against the boards. By this method the heat of

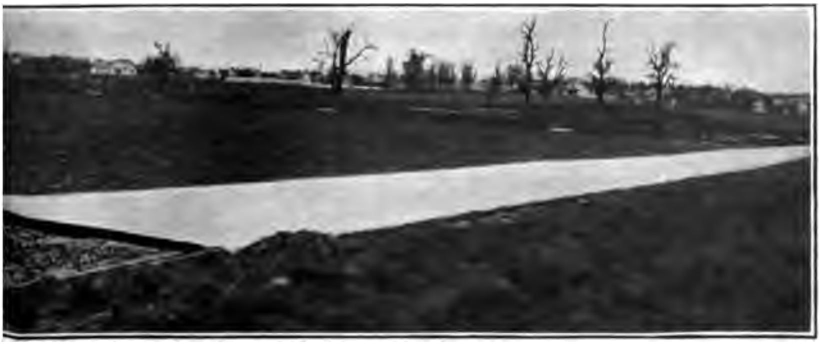


FIG. 4.—Tobacco plant bed with canvas stretched over it.

bed is considerably increased, especially at night, as the canvas vents much of the rapid radiation which would otherwise take ce. During drought the bed becomes excessively dry, and it is en necessary to water it two or three times a week. The bed should not be soaked with water, but should be thoroughly moistened. T best time for watering is late in the afternoon, to avoid baking t soil or scalding the plants.

The canvas should remain on the bed until about ten days pri to transplanting, when it should be removed, in order that the pla may become more hardy and accustomed to field conditions. the canvas remains on too long it is commonly conceded that exc sive leaf growth and too little root growth result. If the plants a growing very rapidly and give indications that they will be rea for transplanting before the desired time, the covering can be remov earlier than indicated; this will to some extent check their growth.

Insect pests sometimes cause considerable injury to the youn plants. In the bed they can be controlled by the use of arsenate o lead—8 pounds in 100 gallons of water, applied with a spray pump This insecticide does not injure the plants in any way and adheres t the foliage very well, being superior to Paris green in this respect.

SELECTION OF SOIL FOR THE CROP.

In the Burley district virgin soil is preferred for the crop. White oak, beech, walnut, maple, and hickory clearings are famous for the production of tobacco having very fine quality. The yield, however, on these newly cleared soils is not equal to that on old land in a good state of cultivation. Tracts of land that will produce good tobacco are limited even in the principal tobacco-growing districts. The average farm usually contains only a small area of land that is particularly adapted to tobacco. The soil should be fertile, friable, and abounding in organic matter to produce the best results. Very little virgin soil remains available for cultivation; consequently, tobacco growers are compelled to adopt a substitute. Bluegrass sod produces a fine quality of tobacco and gives a good yield. Clover sod gives a good yield, but the tobacco does not have the bright color that is secured from the bluegrass sod. Timothy sod is also used for tobacco, but it is not as good as those already mentioned.

No fixed and unchangeable method of rotation is practiced, though some general principles are observed with reference to preceding and succeeding crops. The usual plan of rotation is to have tobacco follow a sod of bluegrass, clover, or timothy and in turn be followed by winter grain, such as wheat, rye, or turf oats. Tobacco follows tobacco for two or, perhaps, three years when virgin soil or bluegrass sod that has not been cultivated for several years is used. The crop of the second year is usually superior to that of the first year in that it has better body and more weight. The third-year crop is often disappointing unless the soil is very fertile in the beginning. It is generally believed that six or eight years of bluegrass sod are required to restore soil to its native productive capacity, particularly with reference to the quality of the tobacco produced. Farmers who make an effort to grow a fine quality of tobacco and at the same time maintain the fertility of the soil practice the sowing of bluegrass along with clover and timothy in wheat following tobacco. In three or four years the bluegrass practically replaces the clover and timothy and will maintain a sod indefinitely. After the field has been used for three or more years for pasture it is again available for tobacco. Below is shown how this eight-year rotation is carried out. The grass or clover printed in italics is the predominant one for the particular year shown. It is assumed that a fertile virgin clearing or bluegrass sod is used to begin with.

(1) Tobacco.
(2) Tobacco.
(3) Wheat.
(4) *Clover, timothy,* bluegrass.
(5) *Clover, timothy,* bluegrass.
(6) *Timothy,* bluegrass.
(7) Timothy, *bluegrass.*
(8) Bluegrass.

Bluegrass is slow in forming a heavy sod. Advantage of this is taken by securing two crops of clover and timothy. When a four-year system is in vogue the rotation outlined below is common:

(1) Tobacco.
(2) Wheat.
(3) Clover and timothy.
(4) Clover and timothy.

To give an accurate idea of soil requirements, Mason County, Ky., may be taken as a fair representative of the Burley district. It is especially selected for illustration because it is included in the Hagerstown clay formation district, which is probably the finest tobacco-growing section of the country. The soil is a heavy brown or pale yellow loam resting on a stiff yellow clay. The Hagerstown clay was formed by the decomposition of limestone of the Upper Hudson of the Lower Silurian era. On the flat tops of some of the hills and on virgin forest areas a loose brown loam may be found. At one time the Hagerstown loam in all probability covered the area now occupied by Hagerstown clay. Continued erosion has carried the greater part of the surface soil away and in many sections the exposed limestone is outcropping. This section of the country is decidedly rolling, and frequently hills with an elevation of considerable magnitude are seen. This land produces on the average about 1,000 pounds of tobacco to the acre.

In the dark-tobacco district, virgin soil on beech, maple, hickory, white oak, red oak, and black jack clearings produces the finest quality of tobacco and is preferred to old land even though it be in a fine state of cultivation. As in the Burley district, clearing has gone on until a relatively small percentage of the land remains in forest. Farmers who have no virgin or "fresh" land to [illegible] tobacco usually prefer clover sod to anything else. Frequently tobacco follows corn and seems to give good results.

Perhaps a definite rotation is more strictly observed in the dark district than in the Burley district. In some localities the following rotations, which have nothing in particular to commend them, are practiced:

(1) Tobacco.
(2) Wheat.
(3) Wheat.
(4) Clover.

(1) Tobacco.
(2) Wheat.
(3) Clover.
(4) Corn.

The use of some leguminous crop is particularly needed throughout this district. Hairy vetch (*Vicia villosa*) could be used to good advantage as a winter cover crop where tobacco follows tobacco. It is a leguminous crop, gathers nitrogen from the air, and grows well in some localities of the dark-tobacco district. It should be sown early in the fall at the rate of half a bushel of vetch and half a bushel of rye to the acre, or, if preferred, some other winter grain may be used. Vetch produces a trailing vine which must be supported by some other crop; if the vetch is to be plowed under in early spring before a very rank growth is attained, however, but little winter grain will be needed to support it.

A typical soil in the dark-tobacco district is that of Montgomery County, Tenn. This Clarksville silt loam of Montgomery County is a residual soil, formed by the decomposition of St. Louis limestone. The action of the air and water dissolves the calcium carbonate, leaving behind the insoluble portions of the rock, which disintegrate to form soil. The surface of this soil has a grayish, very fine silty texture. The subsoil is a yellow loam containing considerable silt and some clay. For some localities in this section a considerable quantity of chert is present, which aids in drainage. Underneath the loam subsoil is a heavy impervious red clay. This serves as a reservoir to hold in reserve moisture for growing crops in time of drought. The surface is somewhat irregular; besides being rolling there are numerous depressions caused by old sink holes. These are usually porous enough in the bottom of the basin to secure good drainage.

The soil and climatic condition of Montgomery County, Tenn., seem to be most favorable for the production of that fine, dark, export type of tobacco so highly prized in European countries.

A more complete discussion of the soil types may be found in the reports on the soil surveys of Mason County, Ky., and Montgomery County, Tenn., by the Bureau of Soils of this Department.

TIME TO BREAK THE GROUND.

Virgin soil where heavy clearings have been made and where there is no grass to contend with may be broken in the spring, sufficient time being allowed to put it in good tilth before planting.

Bluegrass sod and hillside land are usually broken in the spring. The former may be broken in the fall, and in any case should be broken early enough for rotting of the sod to take place before transplanting time. The sod should be turned under so deeply and thoroughly that in case it is not completely rotted it will not be pulled to the surface by subsequent cultivation. Clover and timothy sod should be broken in the early spring. In that way it serves as a winter cover crop for the land and is sufficiently rotted to be out of the way by planting time. Where tobacco follows corn the ground is usually broken in the spring, early enough to keep down a growth of vegetation. Where tobacco follows tobacco a cover crop of rye, winter or turf oats, or barley should be sown. This must be turned under sufficiently early for the green crop to rot. Frequently tobacco follows tobacco or tobacco follows corn and the ground is allowed to go over winter without any kind of cover crop, but this is a bad system and should not be practiced.

FERTILIZERS.

Where fertilizers are to be used, it is best for farmers to buy the ingredients and do their mixing at home. This is less expensive than buying the commercial goods, and by doing their own mixing the farmers familiarize themselves with the amount of plant food in the raw materials. By acquiring this knowledge they will be better posted as to their intelligent use. If a commercial or mixed fertilizer is to be bought it is best to buy a high-grade article, one running high in those elements in which the soil is deficient. The low-grade and low-tonnage-price fertilizers are the most expensive. Farmers pay on the average 2 cents a pound more for plant food—nitrogen, potash, and phosphoric acid—in a low-grade fertilizer than for that in a high-grade fertilizer. In some instances they pay as much as 6 cents a pound more for plant food in a low-grade fertilizer than they have to pay for it in a high-grade article, besides having to pay twice the amount for freight, sacks, and mixing to get the same quantity of plant food.

In the Burley district, where the tobacco is usually set about 18 inches in the drill, the fertilizer is scattered along in the rows, but where the tobacco is checked the fertilizer is dropped in the check. Fertilizers are sometimes applied broadcast, which is a better practice than the methods usually employed. A quicker start may be had by hill fertilizing, but a better season's growth should be produced by broadcasting, especially if the crop passes through a drought, as placing concentrated, quick-acting, soluble fertilizers too close to the roots of the young plants may injure them.

In the dark-tobacco district the usual practice is to set the tobacco in check rows and apply the fertilizer in the checks. If a drought occurs during July or August, hill-fertilized tobacco will fire worse than that broadcasted, for the reason just mentioned. The fertilizer usually gets the blame for this, while the fault lies in the method of application rather than in the fertilizer.

It is impossible to prescribe a fertilizer formula for tobacco suited to all conditions. Varying quantities of potash, nitrogen, and phosphoric acid may be required, depending on the fertility of the soil and the kind of season. By reference to Bulletin 66 of the Kentucky Agricultural Experiment Station, it will be seen that an application of potash or potash and nitrogen gives good results in the limestone region, while in western Kentucky, where the soil is deficient in phosphoric acid, actual field tests have shown that an application of phosphoric acid gives good results.

Tobacco is sometimes regarded as a potash plant, in that 1,000 pounds of crop take more potash from the soil than is taken by the same number of pounds of most crops; in fact, tobacco removes several times as much as is taken by the common crops, such as corn, wheat, cotton, and hemp. Sulphate of potash is found best adapted for tobacco. The chlorin in muriate of potash is considered injurious to both the growing plant and the manufactured article. Tobacco stalks make a valuable manure and should be hauled out and turned under in the early spring. Barnyard manure is not to be recommended where a fancy, highly colored Burley tobacco is to be produced. It can, however, be used to good advantage where a great deal of weight and body is demanded. Generally speaking, barnyard manure has a tendency to produce a coarse tobacco.

PREPARATION OF THE SOIL.

After breaking, the soil should be thoroughly harrowed and rolled, in order to reduce all clods and leave the surface smooth and mellow.

If a crust should form before transplanting, a light harrow or weeder should be used to break it. This prevents the soil from becoming dry and hard, stops excessive evaporation of moisture, and less rain will be required to afford a season suitable for transplanting.

Laying off the ground is the final operation before transplanting. A good implement for doing this is a marker constructed similar to the one shown as figure 5. A marker 7 or 8 feet long will mark off three rows in one drive. The indicator arm makes a slight mark sufficiently distinct to center with the tongue on the return trip. The arm is so constructed that it can be reversed to the other side on the return trip. For setting tobacco where it is desirable to have it 18 inches in the drill, the marker shown in the cut will lay off five rows and insure an equal number of plants to each drill. This implement does not furrow the ground: it only makes distinct crosses and the plants are set in the crosses.

the Burley district the plants are set in rows 3½ to 4 feet apart sually from 18 to 24 inches in the row. A greater distance en the plants, especially on rich soils, produces a coarseness of that is undesirable. Plants set on poor soils should be farther than those on rich soils in order to secure the desired growth.

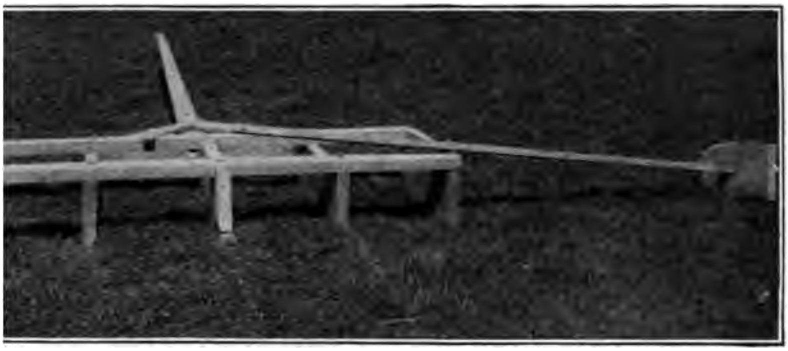


FIG. 5.—Marker used for laying off the rows for tobacco plants.

e dark belt the common practice is to plant 3½ to 4 feet each way ultivate in both directions.

e old method of transplanting by hand is still exclusively used me localities. The accompanying illustration (fig. 6) shows yle of peg commonly used in setting the plants.

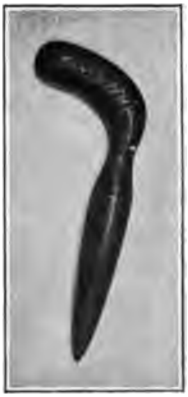


FIG. 6.—Peg used in transplanting tobacco seedlings.

2-horse tobacco setter is used to some extent, ially where there are large fields. With this ine about 3 acres a day can be set, three men a team being required for its operation. Its est advantage is that the crop can be set re- less of season. Growers claim that a larger ntage of plants will live when set by a planter when set by hand.

strict rule of procedure for the cultivation of co would be valueless, since soil and climatic itions are so varied in the different sections he country. Then, too, farmers have dif- t kinds of tools and each one will adjust his ods to suit his supply of farm machinery. a general plan of procedure will therefore be sted.

first, use is made of a shovel cultivator or turn plow (fig. 7), ather close and deep, the object being to stir the soil near the so as to admit air and warmth. Subsequent cultivation consists allow plowing for the purpose of preventing the growth of and conserving soil moisture. The use of any tool that will carry out this purpose will give good results. The hoe is not used in tobacco cultivation so much as formerly unless the hills become infested with grass and weeds. It is used very little in the Burley district. Hilling, following the last plowing, is still considerably practiced in the dark-tobacco district. There is a common impression that it produces a heavier tobacco. Cultivation is not continued to any extent after the plants have grown so large that they would be injured from broken leaves and disturbed root systems.

TOPPING.

When fourteen to eighteen leaves appear on a plant of the Burley type or ten to fourteen on one of dark tobacco, the top is broken out so that the leaves will spread and attain the proper body and thickness. Topping requires considerable discrimination on the part of the grower. He must be able to judge the capabilities of the individual plant and also the soil in which it grows. A slow-growing plant should not be topped as high as a rapid grower. The former will not mature as many leaves as the latter. For the same reason, plants grown on poor soil should not be topped as high as those grown on rich soil. Good judgment should be exercised in topping the plants so that they will all produce leaves of equal body, all of which will ripen at the same time. This end, of course, can be attained only approximately. High topping tends toward late maturity. An experiment on Burley tobacco at the Kentucky Agricultural Experiment Station in 1906 gave best results when the plants were topped at fourteen to sixteen leaves. The plots used had been in bluegrass sod for a number of years and were very fertile. In a second experiment plants were

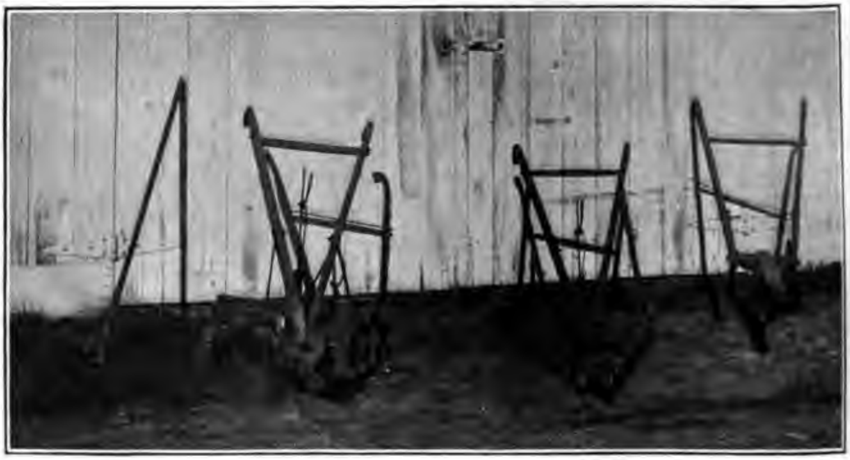


FIG. 7.—Implements used in the cultivation of tobacco.

topped at twenty leaves, but did not produce any more pounds per acre and the tobacco was much lighter in body. Topping at twelve leaves reduced the yield very materially, especially of the bright and red leaf grades. The custom in the dark district is to prime off about four leaves next to the ground and then top from eight to ten leaves on poor soil and from ten to twelve on fertile soil.

After topping the plant, suckers are produced at the axils of the leaves. The first crop of suckers appears soon after the plant is topped, the larger ones in the top of the plant. A short time after their removal a second crop appears. The suckers are removed when they attain a length of 3 or 4 inches. They should not be allowed to remain on the plants after they get of sufficient size to be easily removed. The building material that would otherwise go into the suckers should go to the production of leaf. Very large suckers will cause the leaves to break off by pushing them partially loose from the plant, and their removal leaves ugly scars where they were formerly attached, in which rot and fungous growths sometimes occur.

METHODS OF COMBATING INSECT PESTS.[a]

There are several blowing devices for applying Paris green to destroy insect pests. A simple one consists of a bellows duster that costs about $1. The operator should be careful to dust the poison on evenly and not excessively. Burning will occur in spots on the leaves, and sometimes the whole leaf is affected. From one-half to 1 pound of Paris green is sufficient to apply to an acre of Burley tobacco, the quantity depending on the size of the plants. A less amount should be used in the dark district. Paris green is effective in destroying young worms; but large ones are not held in check very much by it, so that hand picking must be resorted to. It is necessary to apply Paris green every ten days or two weeks in dry weather, and oftener in rainy weather.

Another method of combating the hornworm, and one which might be very successful if adopted by all of the tobacco growers, is the feeding of cobalt to the moths by applying it in the flowers of the jimson weed (*Datura stramonium*). The moths frequent these flowers during the evening twilight and suck the juices found in them; after they have taken some of this poison they become sick and die.

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[a] A discussion of the insect enemies of tobacco is given in Farmers' Bulletin No. 120, entitled "The Principal Insects Affecting the Tobacco Plant," which may be obtained gratis on application to this Department. For further information in regard to these pests or methods for their control application should be made to the Bureau of Entomology, which is engaged in the special investigation of insects affecting this plant. Correspondence will be greatly facilitated if specimens of insects accompany letters of inquiry or complaint.

The cobalt solution should be made up at the rate of 1 ounce of cobalt to 1 pint of sweetened water. A few drops of this solution placed in the newly opened flowers each day will destroy the moths as fast as they appear. The jimson weed is sometimes set out around the field to entrap the moth in this way. Perhaps it would be better to set out the weed at some distance from the tobacco field, as moths in very large numbers seem to be attracted to the field by the flowers.

In the section referred to there are two periods when the worms are particularly numerous. The first visitation occurs early in July. The tobacco being small, as a rule no material damage is done. One month later a second visitation occurs that is much more serious, as the tobacco is large and the pests can conceal themselves with more ease.

SELECTION OF SEED PLANTS.

The selection of seed plants requires the grower's careful discrimination. The average farmer with a few acres should reserve ten or twelve choice plants for seed production. Out of this number he can save two or three that particularly suit his fancy. In a general way plants having leaves of good width and length are desirable. It does not follow that the biggest are necessarily the best, for coarseness is often correlated with size. The leaf should be thick and gummy and of good texture. The veins of the leaf should be far apart and at right angles to the midrib. The character of the veins should be observed and coarseness avoided. Coarse veins in the cured product injure its sale and limit the uses to which it can be put. Long internodes—distances between the leaves—are not desirable and are associated with coarse stalks, which are difficult to cure. It is commonly believed that it is better for the stalk to cure as soon after the leaf as possible. So long as the stalk is green it supplies moisture to the leaves, rendering them darker in color than they otherwise would be. In Burley tobacco, so far as color is concerned, the lighter colored green stalk is an indication of tenderness and that the tobacco will cure readily.

The seed plant should be selected by the time the " button " appears. All leaves except the number desired should be removed. A few days after the first selection the flowers will be blooming. A 12-pound manila paper bag should be placed over the head (fig. 8), so as to protect it from cross-fertilization. The procedure in bagging seed briefly alluded to here is based on the methods devised, developed, and introduced by the Bureau of Plant Industry. Details of these methods may be found in the Yearbook of the Department of Agriculture for 1904 in an article entitled " The Improvement of Tobacco by Breeding and Selection," by Mr. A. D. Shamel.

ʳ of the flowers have opened previous to bagging they should ved, as in all likelihood they have been visited by insects and tilization has been accomplished. After the bags have been t a week they should be temporarily removed and the seed amined. All superfluous branches should be removed; also l leaves, leaving only the " crow foot," bearing from forty to ods. Weekly attention will be required as new blossoms, and leaves which require elimination are produced. The y be permanently removed after twenty-five days, but all opening bags have oved must d off. aturity of l head is l by the turning The heads aken from and hung dry, well- d place for . Precau- hould be o prevent birds from ing them. is recom- d because ental evi- hows that lized seeds ce much iform and lants than omiscuously fertilized (fig. 9). Cross-fertilized seeds produce f widely varied characters, owing to the infusion of so many strains. A certain plant is selected as an ideal; it is desirable tuate its qualities. This can be accomplished only by exclud- side pollen. Darwin's experiments show that self-fertilized seeds have much greater prepotency than cross-fertilized seeds.

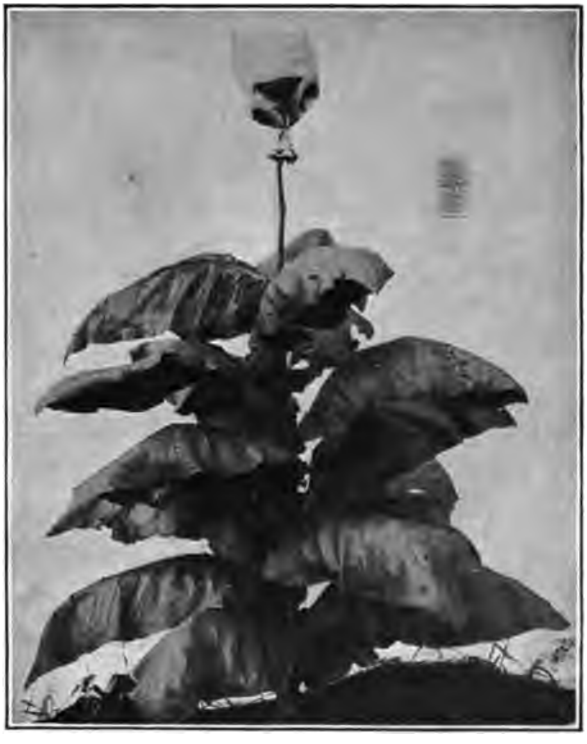

FIG. 8.—Seed head of a tobacco plant protected from cross-fertilization by a paper bag.

HARVESTING.

ess of the plant is indicated by the appearance of yellow spots af and by the brittleness of the veins. Usually about thirty days after topping, the plants are ready for harvesting. The stalks are split with a knife of the kind shown in figure 10, beginning at the top and splitting to within 6 inches of the ground, and are cut from the hill just below the ground leaves.

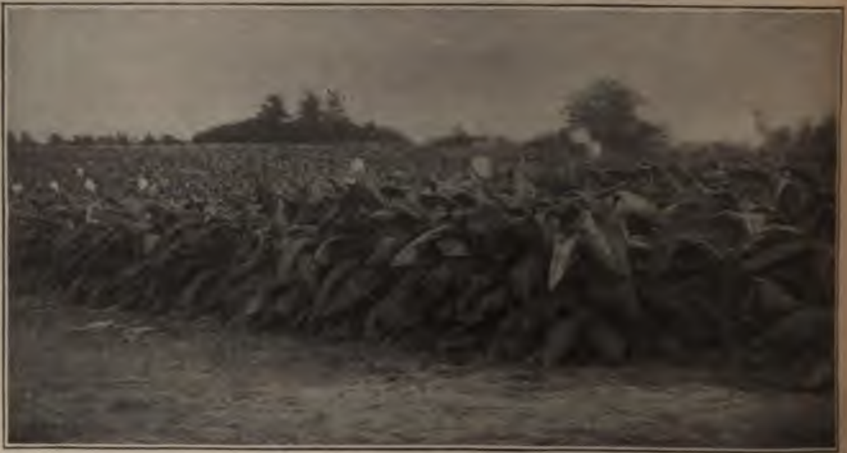

FIG. 9.—Field of White Burley tobacco grown from seed matured under bag, only the heavy seed separated by machine being used.

Five or six plants, the number depending on their size, are placed astride a stick. Within four hours if the weather is favorable the plants will wilt enough to be taken to the barn. To prevent sunburn, it is often necessary to "scaffold" immediately after cutting. Tobacco can remain on the scaffold for two or three days, or longer if necessary. Rain will not damage it much if it has not commenced to cure. Tobacco that has yellowed well on the scaffold before taking to the barn is less likely to house-burn than if it is housed on the date of cutting, before it thoroughly wilts. In handling the crop all possible precautions are taken to prevent injury by bruising.

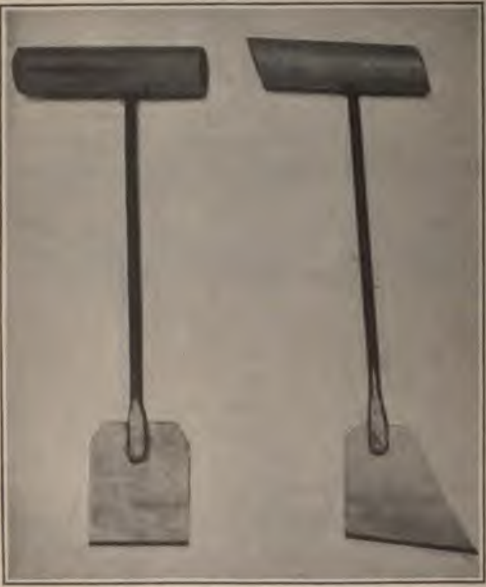

FIG. 10.—Knives used for cutting tobacco plants in harvesting.

A good frame for hauling tobacco is shown in the accompanying illustration (fig. 11).

CURING.

In the barn, sticks filled with the green plants are hung about 10 inches apart on the rails, which are usually 4 feet apart, these rails being about 4 feet apart vertically. Shaking the plants when they are being hung in the barn will prevent the leaves sticking together, which is a frequent cause of damage from house-burn, the texture and elasticity of the leaf being practically ruined when thus affected. Even if house-burn is not produced, uneven coloration is likely to result if the plants are not shaken.

The prime requisite of a barn for air-curing is that it shall be thoroughly ventilated (fig. 12). What is termed side ventilation is popular in the Burley district, i. e., the air is permitted to pass in at windows on one side of the barn directly through and out of windows on the opposite side. The old method was designed to admit air at the side and provide an exit at the top. The movement of the air is effective in driving a current through the barn and is more likely to give good results than is dependence upon a rise of temperature to carry the draft out at the top. For the protection of tobacco hanging in the comb of the barn some ventilation at the top can be provided, since tobacco in this portion of the barn is not much affected by the side draft. To accomplish the ventilation desired, windows should be arranged horizontally the full length of the barn, parallel with each tier, so that a current of air may pass between the butts and the tips of the tobacco on each set of rails. The windows should be about a foot wide and the length of a bin, usually 12 feet. Ventilators about 2 feet square may be located every 25 feet in the comb of the barn.

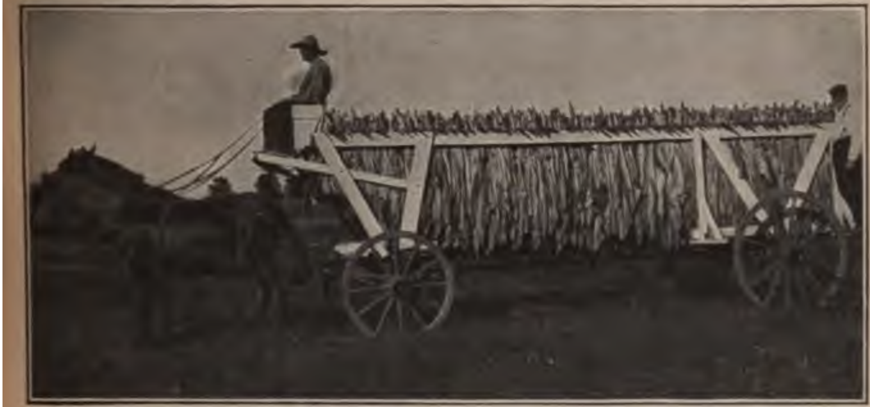

FIG. 11.—A good frame for hauling tobacco to the barn.

The general principle upon which air-curing proceeds is that the tobacco dries during the day and comes " in case," or takes up moisture, during the night. The barn should be opened in the morning, kept open all day under normal conditions, and closed at night during damp weather. During dry weather while the tobacco is curing it is desirable to keep the barn open both day and night unless strong winds prevail which would break or bruise the tobacco.

The most trying time is during fogs and warm drizzling rains when there is very little air stirring. Under such circumstances the air on the outside is saturated with moisture and the barn should be kept closed until the air reaches the saturation point within, which will be indicated by the sweating of the tobacco. Then it is better to open the barn and get the benefit of whatever draft there may be outside. Open fires of coke or charcoal are placed about on the floor of the barn whenever the draft is insufficient or the humidity so great that sweating continues. This creates a draft and increases the water-holding capacity of the inclosed air. Sweating may continue for forty-eight hours without serious injury, but if continued longer than this house-burn may occur and render fires imperative. The first two weeks is the critical period of curing; if no damage has been done at the end of that time the tobacco is comparatively safe. But even then, unless there is a very humid atmosphere, the barn should not be closed so tight that the air can not circulate through it. Two

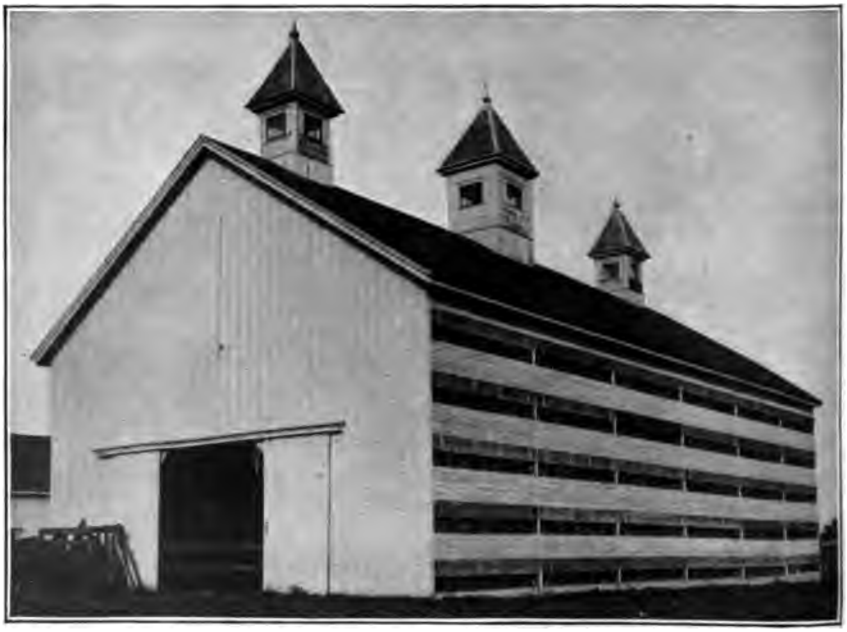

FIG. 12.—A well-ventilated barn for air-curing tobacco.

are ordinarily required before a crop is sufficiently cured to
d and stripped out.

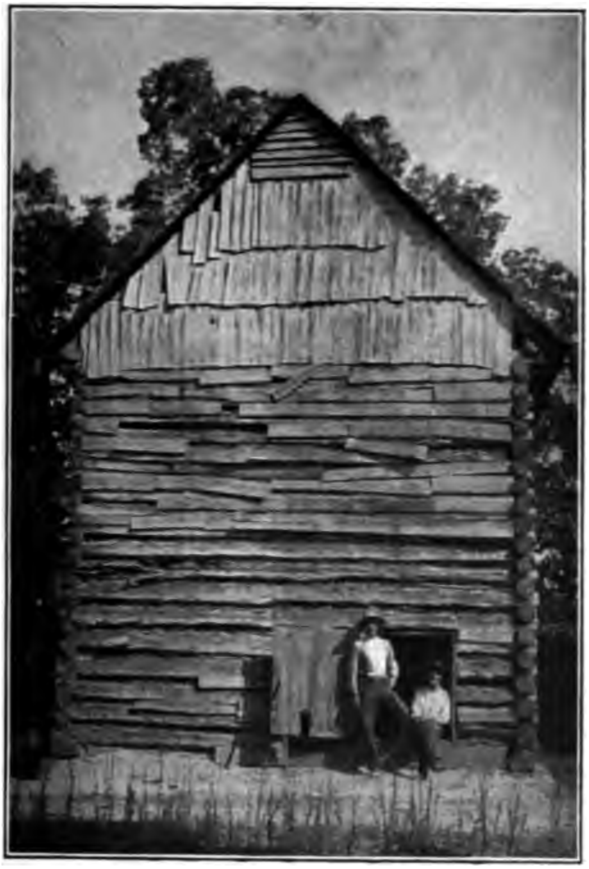

FIG. 13.—A log barn still used for fire-curing tobacco.

› dark-tobacco belt fire-curing is practiced. The sticks are
to about 6 inches apart on the tiers, the space being gov-
some extent by the size of the tobacco, and very little regard
to ventilation. About five days after the crop has been
(fig. 13) the yellowing process is completed and firing be-
f indications of house-burn should occur earlier it will be
y to begin
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tinued for
short time. "Running" is not practiced as much as for-
y many of the best growers. A common mistake is made
npting to cure the crop too quickly, and green and off colors
Careful planters often fire for about ten days. Wood—
and oak are preferable—is used in firing. The odor and
nparted to tobacco by the smoke of wood are necessary where
t is made to produce a dark export type. Coke and charcoal

impart no flavors and for this reason are invaluabl cases when Burley tobaccos are being cured.

STRIPPING AND GRADING.

Planters take advantage of rainy days during the their crop. The moist air brings the crop in case so bulked in large piles; then it will not go out of case return. Care needs to be exercised not to bulk toba not in case sufficiently, because it will be difficult breaking will occur. If tobacco is going out of case it will continue to go out and become dry. Very hig guarded against, as tobacco will become very dark i pecially if much rainy weather follows. Bruising is when tobacco in high case is handled. Tobacco bu "winter order" during the winter months will fu months of April and May if not taken up and hung ba to dry out. After June it can be taken down and bu in "summer order"; then it will keep for years.

Burley tobacco is assorted into five different grades the color and body of the leaf. Beginning at the bas the grades come in regular order as follows: Flying bright leaf, and red leaf. The flyings are the light cl the base of the stalk; usually one or two leaves from in this grade. The trash is a little better grade than tl is usually of a bright color. The next grade is the l of a bright color, and like the trash command the bes market. The bright leaf is the finest grade in appea quently does not sell for so much per pound as the lugs. From these bright grades already mentioned a called "cigarette" is sometimes made. This includes and brightest leaves, practically free from dark colors the top leaves of the plant and is not so valuable as tl The general principle to be observed is to secure unifor ties within the same grade.

Dark tobacco is graded according to the same princi grade should be put in a hogshead; if it is necessary to put in more, they should be separated by a layer of paper. The more attention that is given to careful packing, so as to avoid a mixture of grades within the same bulk or cask, the more satisfactory sale returns will be received.

Tobacco packed during the winter, in winter order, will not keep through what is termed the May "sweat." To prevent it from funking and rotting during this sweating period one must take it up and dry it out, after which it may be repacked in June order; then it will keep indefinitely.

Burley tobacco is bought largely to supply the home market. It is used in the manufacture of smoking tobacco, cigars, and plug for chewing. Great Britain imports a considerable quantity of Burley tobacco for the manufacture of plug. The bright red leaf formerly furnished from the Green River district is now being supplied in part from the Burley district. Germany takes a considerable quantity of the inferior grades. Other European countries use limited amounts.

Fire-cured tobacco is superior to Burley in keeping quality. Dark tobacco packed in good condition during the winter months can be relied upon to pass through the May sweat. It is a good practice, however, to prize this tobacco in June order.

Dark tobacco is used mainly for export purposes and is particularly sought by English, German, Italian, French, Spanish, and African dealers. Sharp lines of distinction are hard to draw between many of the export types. Intermediate grades are generally sought by more than one market. Italian buyers would not hesitate to take certain Austrian grades if they could get them at Italian prices. If there is a shortage of Bremen tobacco, the manufacturers, through their representatives, at once proceed to buy the nearest approximation to the desired type.

In a general way the following classification applies to the export tobaccos: The English market takes grades varying in color from a bright red to a dark brown. The German market in former years preferred an article varying from a chocolate to a full brown color, rich and oily, of good body and strong, elastic texture. In later years there has been a growing demand for brighter colors. A strong, elastic texture is required for the English and German spinners, as the tobacco is twisted into a long coil after the fashion of a rope.

The Italian market takes grades ranging from a cherry red to a deep brown color, the better grades having a smooth, silky finish. The scale of qualities is represented alphabetically. *A* refers to the best grade and consists of a leaf from 25 to 26 inches long and of fine texture and fiber. This type is used largely for cigar wrappers. Grades *B* and *C* measure from 22 to 25 [illegible] to 22 inches, respectively, and approach the quality of *A* as n possible. Intermediate grades are designated as *AB* and *BC* tobaccos are utilized mainly for cigars.

The types exported to Austria are regarded as of a higl than the Italian and consist of grades of lighter shades of col Austrian type lacks the body of the Italian, but possesses finish and silkiness.

The wrapper demanded by the Swiss, which measures from inches, is usually regarded as the highest development of trian type.

The French and Spanish trades require the extreme of tl bodied tobaccos. The better French classes command a ve price, while the Spanish is a cheap, nondescript tobacco.

The type of tobacco required in Africa consists of a very lo row leaf with plenty of body but coarse fiber and grain. Fi quality are not considered. Tobacco for this trade is usuall "balers."

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ng is a list, by number, of the Farmers' Bulletins available for
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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 344.

THE BOLL WEEVIL PROBLEM,

WITH SPECIAL REFERENCE TO MEANS OF REDUCING DAMAGE.

BY

W. D. HUNTER,
In Charge of Southern Field Crop Insect and Tick Investigations,
Bureau of Entomology.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agricul
Bureau of En
Washington, D. C., Nove

Sir: I have the honor to transmit herewith the
paper, by Mr. W. D. Hunter, agent in charge of so
insect and tick investigations in this Bureau, deali
weevil, especially with reference to means of reducing
many publications upon different phases of the boll
have been issued by this Department during the year
has invaded the United States that it has seemed a
sent a summary in a single paper of the practical
therein and including the results, as yet unpublish
recent investigations. This purpose has been car
present paper, the publication of which as a Far
hereby recommended, superseding No. 216.

Respectfully, L. O.
Entomologist and Ch

Hon. James Wilson,
Secretary of Agriculture.

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ILLUSTRATIONS.

FIG. 1. Map showing area infested by boll weevil in 1908 and during various preceding years

2. Cotton boll weevil: Beetle

3. Cotton boll weevil: Larva, pupa

4. Cotton square showing egg-puncture of boll weevil and "flaring" of bracts

5. Cotton square showing boll-weevil larva in position

6. Chain cultivator, side view

7. Work of the chain cultivator: Cotton row before use of cultivator, showing fallen squares, crack, and rough condition of ground

8. Work of the chain cultivator: Same row shown in fig. 7, after cultivator has passed; majority of squares brought to middle, crack filled, and dust mulch established

9. Apparatus for fumigating cotton seed in the sack

IE BOLL WEEVIL PROBLEM, WITH SPECIAL REFERENCE TO MEANS OF REDUCING DAMAGE.

INTRODUCTORY.

This bulletin, dealing with work done under the direction of Dr. O. Howard, Chief of the Bureau of Entomology, is intended to er in a general way the whole field of the control of the boll vil. As this control is inseparably connected with the life hisy and habits of the insect and, in fact, must be based thereon, attion is given to the principal features of the insect's economy. In dition, information is given relating to the amount of damage ne, the extent of the infested territory, and such other matters are of special interest at this time.

Like many of the most important injurious insects in this country, e cotton boll weevil is not a native of the United States. Its original me was undoubtedly in the plateau region of Mexico or Central merica, and it may originally have fed upon some plant other an cotton. This is not necessarily the case, however, since there evidence that the same region is the original home of the cotton ant itself. Previous to 1892 the insect had spread through Mexico, t little is known regarding the extent or rapidity of this dispern. The records indicate, however, that it had probably caused abandonment of cotton in certain regions. About 1892 the boll evil crossed the Rio Grande near Brownsville, Tex. It may have wn across, or it is possible that it was carried over in seed cotton be ginned at Brownsville. By 1894 it had spread to a half dozen unties in southern Texas and was brought to the attention of the ureau of Entomology. A preliminary examination, made under e direction of Dr. L. O. Howard by Mr. C. H. T. Townsend, owed the enormous capacity for damage of the pest. Subsequent ents have verified in every way the predictions that were made at at time, when the insect had not attracted any considerable amount attention in the South. Since 1894 the boll weevil has extended range annually from 40 to 70 miles, although in two instances e winter conditions have been such as to cause a decrease in the fested area. During the first ten years after its advent into this untry the annual rate of spread was 5,640 square miles. Since

1901 the annual increase in the infested territory has
26,880 square miles, but in one exceptional season, name
51,500 square miles became infested. Of course, the figu
do not refer to the area in cotton. In many parts of the
territory the area devoted to cotton is much less than 10 pe
the total area.

At the present time the weevil is found more or less ex
in five States—Texas, Louisiana, Mississippi, Arkansas, a
homa. In Mississippi 18 counties are infested, in Arkansas
in Oklahoma about one-fifth of the State. The total area
comprises about 225,000 square miles and this covers abou
cent of the cotton acreage of the United States. (See fig. 1.)

DAMAGE.

The damage done by the boll weevil varies greatly from
year and also in different parts of the infested area. As the
increases the damage becomes greater. In prairie regions, w
insect obtains but little protection through the winter, it i
comes as numerous as in other quarters where favorable c
for hibernation are found. These facts, together with variat
to winter conditions, make it rather difficult to estimate t
damage that has been done. Some years ago the writer stat
the statistics then available, that the weevil caused a reduct
least 50 per cent of the cotton crop in regions invaded by it,
after the first few years the farmers generally resorted t
means to greatly reduce this loss. In many individual cases t
of control perfected by the Bureau of Entomology have been
so successfully that the crop has been fully as large as before
ing of the weevil. This was not accomplished, however, witho
what increasing the cost of production. The estimate of a
falling off in production of 50 per cent was verified by Pro
Sanderson, formerly State entomologist of Texas, who arriv
figures in an entirely different way.

The average yield per acre in Texas from 1893 to 1901 (w
weevil had not done damage sufficient to affect the general
tion) was 0.40 bale. The average since that time, 1902 to 1
0.35 bale. By comparing these periods we have a reasonably
basis for estimating the damage the insect has done. The c
is 0.05 bale, or 25 pounds of lint per acre each year. At curr
this means an annual loss of at least $2.25 per acre which
sustained by the cotton planters of Texas. Assuming that t
acreage has averaged 10,000,000, the total loss for the State h
ally been $22,500,000.

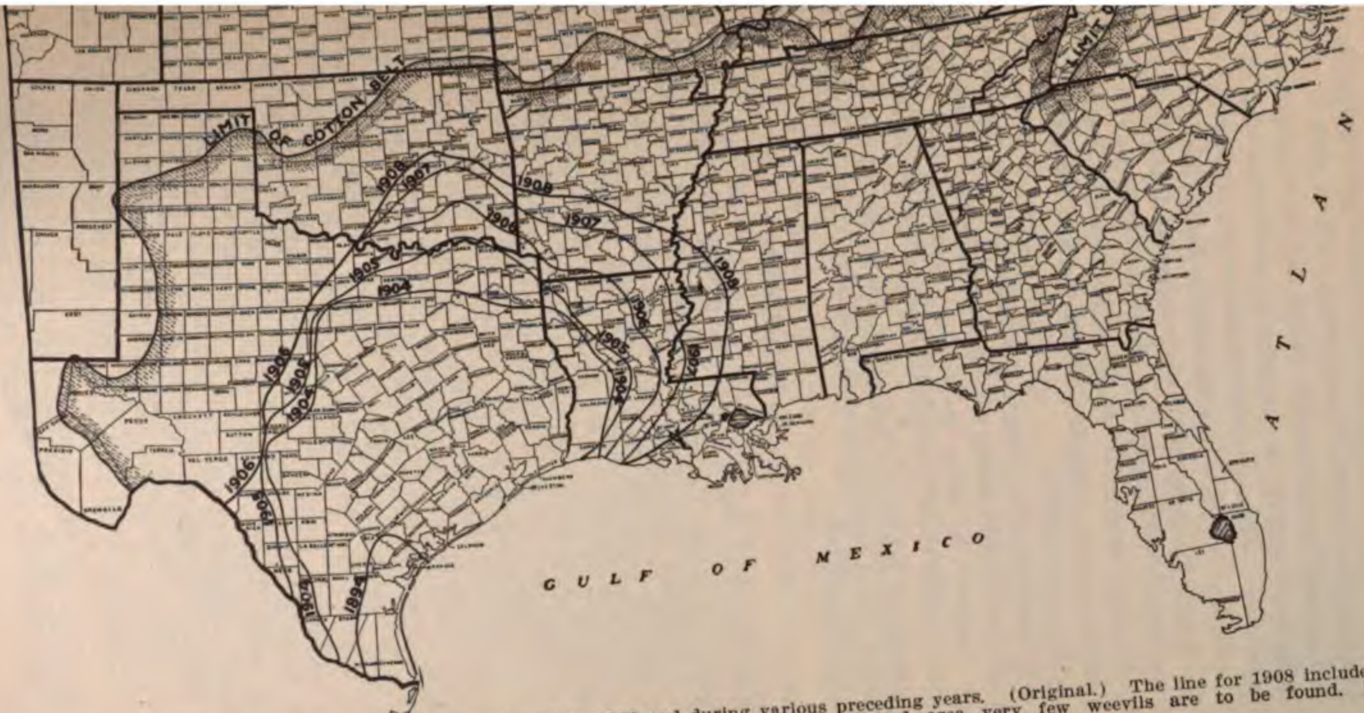


FIG. 1.—Map showing area infested by the boll weevil in 1908 and during various preceding years. (Original.) The line for 1908 includes all territory in which any infestation has been found. Toward the outer part of the infested area very few weevils are to be found. This applies to a belt from 5 to 25 miles wide bordering the line for 1908 on the inside.

Another tangible indication of the manner in which the weevil has affected cotton production is revealed by a comparison of statistics from Louisiana and Texas. From 1899 to 1904 the acreage in Texas and Louisiana increased at about the same proportion, but the crop in Texas decreased at the same time that the crop of Louisiana was increasing. There is an exception to this statement in the years 1900 and 1904, in which the production in Texas did not decrease, but these years were exceptionally unfavorable for the weevil and at the same time very favorable for the general growth of the cotton. In 1907 the yield per acre in Texas (0.24 bale) was the smallest in her history. This followed a winter so mild that more than the usual number of weevils overwintered.

Undoubtedly for several years the boll weevil has caused a loss of about 400,000 bales of cotton annually. Although farmers in older regions, in many cases, are increasing their production, there is loss in the newly infested regions which offsets that gain. A conservative estimate shows that since the weevil has invaded this country it has caused a loss of 2,550,000 bales of cotton, at a value of about $125,000,000.

PROSPECTS.

Reference has been made to the greater damage inflicted in moist regions and where the shelter for hibernation is best. The records of the Weather Bureau show that the annual precipitation increases very rapidly from the West to the East in the cotton belt. This is especially the case during the early growing season of cotton, namely, April, May, and June. The precipitation in the greater part of the cotton-producing area in Texas is normally about 40 inches. In Louisiana, Mississippi, and the eastern States of the cotton belt it is more than 50 inches, and sometimes exceeds 60 inches. The records that have been kept in Texas show that the damage has always been greatest in wet seasons and that the insect has affected land values most where the general conditions approach those of the eastern part of the cotton belt. Without the assistance that is furnished by climatic conditions, especially dry weather during the spring, the farmers of Texas would not have been by any means as successful in producing cotton during the last few years as they have. The system of control outlined in this bulletin increases greatly in effectiveness when assisted by weather conditions. Fortunately in Texas this assistance is given under normal conditions. When this assistance is above the normal, as in 1904 and 1906, the crops will be exceedingly large.

On the other hand, it is clear that the problem of the control [illegible] the boll weevil will be more difficult as the pest continues its invasi[illegible] the cotton belt. It can not be considered, therefore, that the ɔblem is as yet completely solved. Better means of control must devised for the region that is becoming invaded, and, if possible, ans must be devised that will reduce the enormous loss that is fered, especially during unfavorable seasons, in Texas. The prin- al work of the Bureau of Entomology at this time is in attempting devise means for this requisite additional control.

For the present there is no occasion to lose hope. Though the tern planter must expect a more serious problem than that which ıfronted the farmers of Texas, the means of control outlined in s bulletin, especially the destruction of the hordes of weevils about enter winter quarters, will enable him to continue production, ugh probably at a reduced profit. The sooner he adapts his plan- ion management to the necessary changes the less the loss will be.

WORK UPON WHICH THIS BULLETIN IS BASED.

ls has been stated, the danger from the boll weevil was appreciated m the beginning by Dr. L. O. Howard, Chief of the Bureau of tomology. For about ten years, more or less continuous work on vulnerable points in its life history and the possibility of control various ways has been done. At first this was not extensive, hough it showed the essential steps necessary in the control of the t. Later Congress made available large appropriations for the ıaustive investigation of the insect and of means of reducing its mage. Work was begun under the first large appropriation by the ablishment of a laboratory at Victoria, Tex., and the beginning of ensive field experiments. It has been the practice from the be- ıning to carry on field experimental work in direct connection with laboratory investigations. All means of control suggested by the oratory work have immediately been tested on large field areas. ter the headquarters of the investigation were moved from Vic- ia, Tex., to Dallas, Tex., on account of the continued spread of the ect and the necessity for a central location. The Bureau of Ento- logy has conducted experiments during several seasons on a al of more than 10,000 acres of cotton. This experimental work been located on well-known plantations throughout the infested ritory. The special requirements in different regions have been en particular attention. Almost invariably successful crops have n produced, although special damage, due to local conditions in ferent regions, has sometimes interfered with the success of the eriments. The present bulletin contains a very condensed report the results of all this work. The recommendations have all been ced in practical operation under the actual conditions prevailing different cotton plantations.

Aside from the work directly relating to the boll weevil, which has been conducted by the Bureau of Entomology, the Bureau of Plant Industry of this Department has carried on investigations in its province. These have dealt with the breeding of cottons to obtain earliness and productiveness and with the extensive demonstration of the efficiency of the system of control devised by the Bureau of Entomology as the result of careful studies in the field and laboratory.

In addition to the work done by the Department of Agriculture the States concerned have done their part. Several entomologists have been employed by the State of Texas, namely, F. W. Mally, E. D. Sanderson, A. F. Conradi, and C. E. Sanborn. They have dealt with the boll weevil in connection with the numerous other entomological problems of the State and have contributed valuable results that have been made use of in this bulletin. The State of Louisiana has also done very notable work. Prof. H. A. Morgan and, later, Mr. Wilmon Newell, have added considerably to our knowledge of the weevil and the means of controlling it. In many ways their results are incorporated in this bulletin.

DESCRIPTION AND LIFE HISTORY.

The adult boll weevil is about one-fourth of an inch in length, varying from one-eighth to one-third of an inch, with a breadth about one-third of the length. This measurement includes the snout, which is about one-half the length of the body. Variation in size is due to the amount of food the insect has obtained in the larval stage. Individuals from bolls are therefore nearly always larger than those from squares. The color (grayish or brownish) depends upon the time that may have elapsed after transformation into the adult stage. The recently emerged individuals are light yellowish in color, but this passes to a gray or nearly black shade in a few weeks' time. The general appearance of the insect will be evident from the accompanying illustrations (fig. 2).

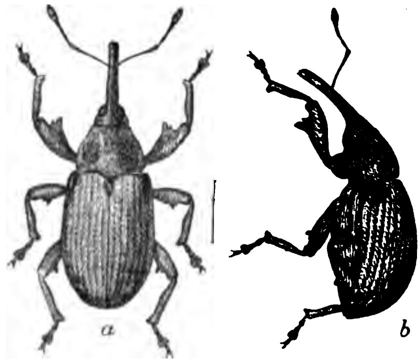


FIG. 2.—Cotton boll weevil: *a*, Beetle, from above; *b*, same, from side. About five times natural size. (Author's illustration.)

Many insects resemble the boll weevil more or less closely. In fact, there are hundreds of species of weevils in this country that may easily be mistaken for the enemy of cotton. Many mistaken reports about the occurrence of weevil far outside of the infested area have been due to mistakes that hav arisen on account of this similarity. The only safe way to determi ether any insect is the boll weevil is to send it to an entomologist r examination. In the field the most conspicuous indication of e presence of the boll weevil is the flaring (fig. 4) and falling of eat numbers of squares. However, unfavorable climatic conditions d careless cultivation frequently use great shedding. If excessive edding be noticed and the squares on being cut open show a white, rved grub (fig. 5) that has fed on the contents, there is little ubt that the boll weevil is the sect causing the damage.

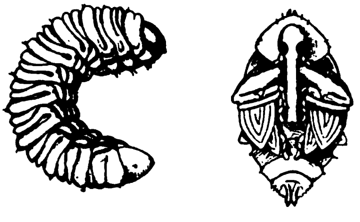
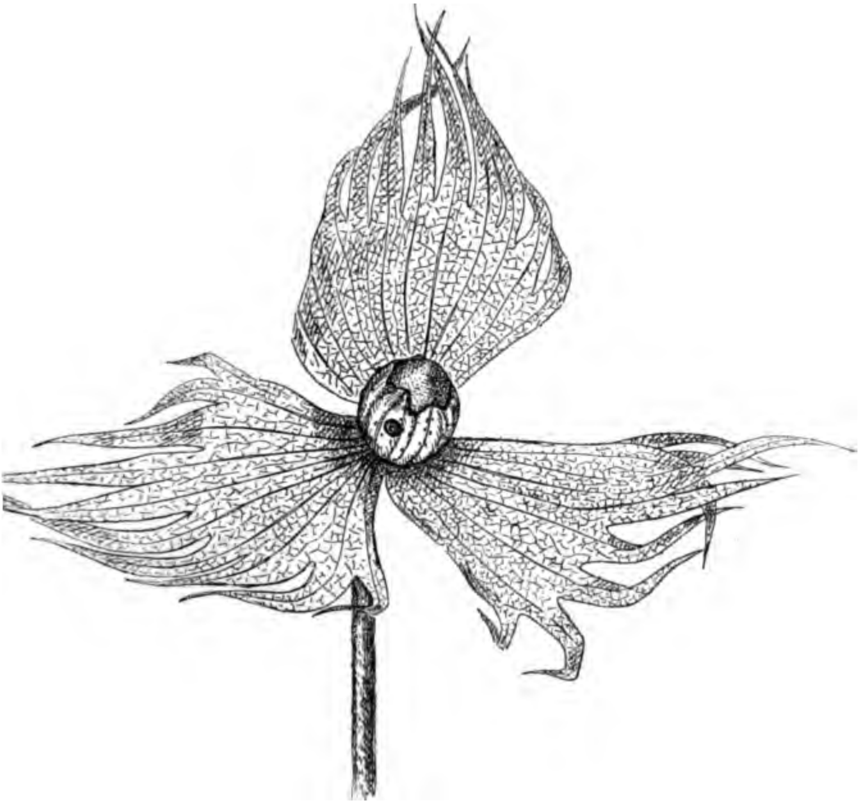


FIG. 3.—Cotton boll weevil: Larva at left, pupa at right. About five times natural size. (Author's illustration.)

The boll weevil passes the winter the adult stage. In the spring and throughout the fruiting season cotton the eggs are deposited by the female weevils in [illegible] rmed by eating into the fruit of the plant (see fig. [illegible]



4.—Cotton square showing egg puncture of boll weevil and "flaring" of bracts. Natural size. (Author's illustration.)

hatches under normal conditions in about 3 days and the grub immediately begins to feed. In from 7 to 12 days the larva or grub (fig. 3, at left) passes into its pupal stage (fig. 3, at right), corresponding to the cocoon of butterflies and moths. This stage lasts from 3 to 5 days. Then the adult issues and in about 5 days begins the production of another generation. Climatic conditions cause considerable variation in the duration of the stages, but on an average it requires from 2 to 3 weeks for the weevil to develop from the egg to the adult. Males and females are produced in about equal numbers. The males feed upon the squares and bolls without moving until the food begins to deteriorate. The females refrain from depositing in squares visited by other females. This applies throughout most of the season, but late in the fall, when all the fruit has become infested, several eggs may be placed in a single square or boll. As many as 15 larvæ have been found in a boll. The squares are greatly preferred as food and as places for depositing eggs. As long as a large supply of squares is present the bolls are not damaged to any serious extent. The bolls, therefore, have a fair chance to develop as long as squares are being formed. Whenever frost or other unfavorable weather causes the plants to cease putting on squares the weevils attack the bolls. A conservative estimate of the possible progeny of a single pair of weevils during a season beginning on June 20 and extending to November 4 is 12,755,100.

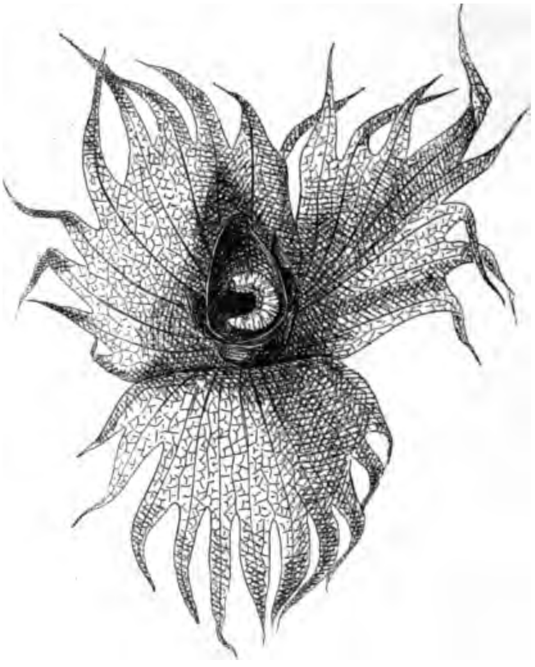


FIG. 5.—Cotton square showing boll weevil in position. Natural size. (Author's illustration.)

The cotton boll weevil, as far as known at present, has no food plant other than cotton. This has been determined by planting various plants related to cotton in the vicinity of infested cotton and in cages in which weevils were placed. It has therefore been demonstrated beyond any doubt whatever that the insect is restricted to the cotton plant for food. When confined in bottles, the weevil will partake of various substances, such as apples or bananas; but this is only under the stress of starvation. Under natural conditions they would pay no attention to these substances.

The boll weevil is strictly diurnal in its habits. Repeated observaions made in the field at night have shown that it is not active after undown. Unlike some related insects, it is not attracted to lights. The fact that somewhat similar species do come to lights in great numbers at times has frequently caused unfortunate confusion.

An interesting habit of the boll weevil is to feign death; that is, to "play possum" or "sull," as it is popularly called. When disturbed, the insects generally contract their limbs and drop to the ground. This habit is not equally strong in all individuals. It has been taken nto consideration in plans of control, as will be described beyond.

The age to which weevils live varies under different conditions. During the winter the longevity is much greater than in the summer. During the summer season the majority of weevils do not live longer han 60 days. During the cooler part of the year many of them live s long as 6 months. The longest-lived weevil on record lived from December 10 to the following October, a period of about eleven months. Undoubtedly such prolonged life is exceptional.

HIBERNATION.

As has been pointed out, the boll weevil passes the winter in the adult stage. In the fall when frosts occur, immature stages may be found in the squares or bolls. Provided the food supply is sufficient, many of these immature stages continue their development at a very slow rate and adults finally emerge. Thus there may be a somewhat continuous production of adults during the winter. Ordinarily, however, this is not conspicuously the case, since the frosts that destroy the cotton generally kill practically all of the immature stages of the weevil.

With the advent of cool weather in the fall the adult boll weevils in cotton fields begin to seek protection against the winter. They fly from the fields in every direction, although their movements are governed partially by the prevailing winds. They may fly into hedges, woods, cornfields, haystacks, farm buildings, or other places. Specimens have been found in such situations, and also in considerable numbers in Spanish moss growing from trees some distance above the ground. A number of weevils also obtain hibernating quarters without leaving the cotton fields. These may crawl into cracks in the ground under grass, weeds, and other trash, and into the burrs from which the cotton has been picked. In some cases several thousand weevils per acre have been found hibernating in such situations. Here, however, the mortality is greater than where the protection is better. The majority of weevils that hibernate successfully do n pass the winter in the cotton fields. This has been shown by man experimental observations, and is demonstrated every year in th infested territory by the appearance of the first damage in the imm diate vicinity of weeds and other places where conditions for prote tion are favorable.

During the winter the weevils take no food and remain practicall dormant. On especially warm days they may move about to a ce tain extent. During the very mild winter of 1906–7 hibernati weevils were found moving about more or less throughout the peri from November to March.

The number of weevils hibernating successfully has been dete mined very accurately for different conditions. Out of 25,000 weevi 2.82 per cent survived the winter of 1905–6. These weevils we placed in a variety of conditions that must have approached tho which weevils must naturally encounter. The winter referred to wa practically a normal one as far as temperature and precipitatio were concerned. In extensive work during the winter of 1906–7, ou of 75,000 weevils 11.5 per cent survived. As in the preceding cas these weevils were placed under diverse conditions in different cage These conditions ranged from the most favorable to the least favor able, i. e., from an abundance of protection to practically none. Th survival obtained is undoubtedly very close to that occurring unde diverse natural conditions of that winter. It must be emphasized that the winter of 1906–7 was abnormally warm. It is undoubtedly true that the rate of survival was much higher than usual. It is supposed that the results of the previous year must approach the average. In other words, less than 3 per cent of the weevils entering hibernation can be expected to survive the winter under average conditions. The tremendous importance of still further reducing this percentage must be evident.

Emergence from hibernation depends primarily upon temperature in the spring, although there are other minor factors concerned. Generally, from the first to the middle of March the temperature has become high enough to cause weevils to begin to emerge. Naturally, the individuals under the heaviest protection are affected latest by the temperature. The consequence is, that emergence from hibernating is a prolonged operation. During one season (1906) it extended from the middle of March to the 28th of June; during another (1907) from the middle of February to about the first of July. During each of these periods there was a comparatively short time—about ten days—of rapid emergence, preceded by an initiatory movement and followed by a period during which the number emerging day by day decreased with rapidity.

HOW NATURE ASSISTS IN DESTROYING THE BOLL WEEVIL.

In the preceding paragraph attention was called to the possible production of 12,755,100 offspring in a single season by one pair of weevils. As a matter of fact, nature has provided a number of agencies that serve to prevent such excessive multiplication. The most conspicuous of these agencies are heat and insects that prey upon the weevil.

Effects of heat.—When infested squares fall to the ground they may become so heated that the larvæ are killed in a very few minutes. The insect in this stage can not leave the square, as it has no means of locomotion whatever. Where the infested squares are subjected to the unobstructed rays of the sun the mortality is very high. This explains the well-known fact that dry seasons are unfavorable to the weevil, and indicates great difficulty in controlling the insects in regions where the precipitation is heavy. The more rankly the plants grow and the more the ground is shaded, the less effect in weevil control can be expected from heat. Nevertheless, in many cases in Texas the enormous total of 40 per cent of all the immature weevils in cotton fields inspected have been found to be destroyed through this agency. It was also found, from examinations in many quarters, that the extent of destruction held a direct relation to the amount of shade. When there was no shade practically all of the larvæ and pupæ were killed outright. Some of the important means of control, to be described later, are based upon this consideration.

Insect parasites.—The second of the important agencies provided by nature for the control of the weevil is a large number of predaceous insect enemies. These consist of a variety of forms which prey upon the boll weevil. Forty-five species of these enemies are known. Of these, 23 are parasites, which by means of their ovipositors place eggs on the immature stages of the weevil within the square or boll. The young of the parasite develops by feeding upon the immature boll weevil, which it ultimately kills. A parasite instead of a boll weevil emerges from the injured fruit. Special studies on these parasites have led to many suggestions for practical control. Moreover, the parasites seem naturally to be increasing in numbers and effectiveness against the boll weevil. In one instance in 1907 the mortality due to parasites in a field near Robson, La., was 77 per cent. About the same time 61 per cent of the weevils in a certain field near Victoria, Tex., were killed by parasites. These enemies of the weevil have existed in the country for an indefinite time. Their natural habit has been to prey upon weevils more or less related to the boll weevil that have occurred in this country for many years. They never feed on vegetation. It is undoubtedly true that they are now turning their attention from the original hosts, which are g erally not very numerous, to the boll weevil, which offers abun and favorable opportunities for reproduction. They thus ally th selves with the farmer for the protection of the cotton crop. In t following pages numerous suggestions will be made regarding t means that the farmers may take to increase the effectiveness of t work of these parasites in reducing the numbers of the boll weevil.

Other insect enemies.—In addition to the true parasites descri above, the boll weevil suffers from a number of insects which are n parasites in a strict sense but prey upon it as food. The princip ones of these predatory enemies are ants. Of these, 12 species a known to attack the weevil. They are the minute brown ants and y lowish ants that occur frequently in cotton fields and are observ running over the plants or on the ground. Their work is not agai the adult weevils, but against the immature stages in the squa Some species devote their attention principally to the squares th have fallen to the ground, while others habitually seek the inse within the squares that remain hanging on the plants. The larva o the weevil, incased in a thin covering, offers a source of food that th ants are not inclined to overlook. They gnaw through the thin sh inclosing the weevil larva and the latter is soon destroyed. In so cases more than half of the immature stages in fields have been fou to be destroyed by ants alone. To find 25 per cent so destroyed is n a rare occurrence. In this bulletin methods will be pointed out fo making use of these friends of the farmer and increasing the important effect they naturally have in reducing the numbers of weevils.

Other factors in natural control.—In addition to the principal factors in natural control which have been mentioned there are several of minor importance. Among these may be mentioned proliferation, which sometimes crushes the immature weevils, and determinate growth, which may prevent the development of the fall broods of the weevil. Attention is also called to the agency of birds in the destruction of the boll weevil, which has been given full attention in the publications of the Biological Survey of this Department.

DISSEMINATION.

The boll weevil moves from place to place by flight. Although it is a weak flyer compared with many insects, it has been known to cover a distance of more than 40 miles in a very short time. Its flight can not be prolonged, but successive short flights, especially in connection with favorable winds, often carry the insect to considerable distances. This is the case, however, only during the so-called dispersion period, which extends from about the middle of August to the end of the season. During the rest of the year the weevil is little inclined to fly. There is always a movement from fields in all directions in search of hibernating quarters in the fall and a corresponding movement from such quarters to the cotton fields in the spring. Nevertheless, when the insects reach cotton fields in the spring there is little further movement until the general dispersion begins. Ordinarily between the middle of August and the first of September the weevil seems to be seized with an instinct to migrate. It was thought at one time that this movement was forced by excessive reproduction and took place only when all squares and bolls, or the majority of them, became infested. Investigations have shown, however, that the dispersion takes place frequently when the fields are only slightly infested. In other words, the insect has a well-developed instinct for extending its range into new territory. It is this instinct that has caused the extension of the infested area in the United States year by year. The weevil does not fly in any particular direction except as governed by the wind. If there is no wind or only a light one, a weevil is as likely to fly in one direction as in another. The individuals carrying the infestation into new regions have been those that happen to radiate in the direction of previously uninfested territory.

The fact that the weevil moves about but little except at one season is of great benefit to the farmer. As the movement referred to does not begin until after the time when a crop is normally made, it amounts to but little after a region has become infested. On the other hand, the limited movement at other times of the year makes it possible for any individual farmer to obtain the best results from his own efforts in fighting the pest. The danger of his efforts being thwarted by the arrival of weevils from fields where no precautions have been taken is not as important as is sometimes considered. In fact, it is not important enough to warrant any farmer in deferring action on account of the indifference of his neighbors.

The above statements give only an outline of the life history and habits of the boll weevil. More complete information can be obtained from Bulletin 51 of the Bureau of Entomology, which may be obtained for 15 cents upon application to the Superintendent of Documents, Government Printing Office, Washington, D. C. In this connection the writer wishes to emphasize the following four important points that have a direct bearing upon control:

(1) It has been demonstrated that the boll weevil subsists on no other food than cotton.

(2) The weevil moves about but little until late in the cotton-growing season; in fact, not until the time when the crop is normally set.

(3) Winter conditions naturally reduce the number of weevils enormously; indeed, the winter is the critical period in the life history of the pest.

(4) Natural agencies operate to destroy a very large percentage of weevils. These agencies are increasing in effectiveness and already are of very great importance to the farmer in reducing his loss. Otherwise it would often be practically complete.

MEANS OF CONTROL.

It will be evident from the preceding statements regarding the life history and habits of the weevil that its control is beset with many difficulties. In fact, it is probably the most serious insect pest that is now known. Its insidious methods of work in the immature stages within the fruit of the cotton plant, the habit of the adult in seeking protection for the greater part of the time under the bracts of the squares, and its enormous power of reproduction and adaptability to new conditions, all tend to place the boll weevil in a class by itself. The difficulties are increased by the necessary procedures in raising cotton. In spite of these difficulties fairly satisfactory means of control are known. A large share of the reasonable success of the warfare against the pest is due to the assistance furnished by natural agencies, which commonly destroy many more weevils in a cotton field than the farmer could by any known method or methods.

Burning infested plants in the fall.—Foremost among the methods of control is the killing of the hordes of adult weevils that are ready to enter hibernation in the fall and the prevention of the development of millions more that would later emerge to pass through the winter. This is accomplished by burning the infested plants in the fall after the weevils have become so numerous that there is no prospect of the maturity of any additional crop. There are many vital reasons why the wholesale destruction of the weevils in the fall should be practiced by every cotton planter in the infested region. Some of these are stated below:

First. Hordes of adult weevils, many for each plant in the field, are killed outright.

Second. Many more weevils that are in the immature stages, possibly as many as a hundred for each plant in the field, are also killed.

Third. The few adult weevils escaping will be weakened by starvation and the great majority will not have sufficient strength to pass through the winter.

Fourth. The development of the late broods, which experiments have shown furnish the vast majority of weevils that pass through the winter, is cut off immediately. In this way hundreds of weevils that would develop from each plant are absolutely prevented from so doing.

Fifth. The removal of the infested plants with the weevils facilitates fall or early winter plowing, which is the best possible procedure in cotton raising. Moreover, this plowing assists greatly in the production of an early crop the following season.

In short, in the fall the weevil is at the mercy of the planter as it is at no other time. If the planter desires to kill the insect he can do so. Work in weevil destruction at that time far outbalances all remedial measures that may be applied at all other times of the year.

Many hundreds of cases are on record showing the benefit from the fall destruction of plants in the control of the boll weevil. The process has not been taken up as generally as it should, but individual instances everywhere show its value. A large amount of experimental work done by the Bureau of Entomology has all pointed clearly toward the supreme importance of this essential method in control. In an experiment performed by the Bureau of Entomology in Calhoun County, Tex., the stalks growing on 410 acres of land were destroyed early in October. Careful records kept during the following season showed that this work had increased the production more than a quarter of a bale per acre over the crop on the check area where such work was not done. Computing the increase in the crop at the current prices, the advantage from the work in the experiment amounted to $14.56 per acre. This was about 29 times the cost of uprooting and burning the plants, as shown by the amount actually paid by the Department for the work. Circumstances surrounding the experiment, referred to in Circular 95 of the Bureau of Entomology, show that the advantage was probably considerably greater than has been indicated here. At any rate, the estimate given is most conservative. In this instance the cotton destroyed was isolated and the results are perhaps somewhat more conspicuous than would have been the case where there were hundreds of cotton fields in the neighborhood. Nevertheless, experience with fields surrounded by others that have been given no attention has shown a great advantage from taking the proper step in the fall. Of course, concerted action will add to the effectiveness of the work and should be followed in every community.

In addition to the field work by the Bureau of Entomology and by many practical planters, a great deal of work has been done in large cages, where the conditions could be studied most carefully. In this way the exact relative advantage of fall destruction at different dates has been determined. It has been shown in this connection that the earlier the work can be done the better the results will be. For instance, seven times as many weevils survived the removal [illegible] fested plants on November 12 as survived after similar work on October 13.

Mr. J. D. Mitchell, of the Bureau of Entomology, calls attention to a striking example of the value of the fall destruction of the weevils that came to his attention in 1908. On opposite sides of the Guadaloupe River near Victoria, Tex., were two farmers, each having about 40 acres in cotton. In one case the stalks were uprooted and burned in September, 1907, and in the other they were allowed to stand until shortly before planting time in the spring of 1908. They were equally good farmers, and the soil was the same on the two places. In the first case the crop of 1908 was 15 bales and in the other 3½ bales. The work done during the preceding fall plainly increased the crop about fivefold.

No definite rule can be laid down as to the proper time for destroying the weevils upon and in the fruit of the plants in the fall. In general, the proper time is whenever the weevils have reached such numbers as to infest practically all of the squares that are being set. This may occur a month or more earlier in some seasons than in others. Fall destruction as late as November will accomplish much, but several times the number of weevils can be destroyed if the work be done in October. Therefore the rule should be to destroy the infested plants at the earliest possible date in the fall. It is much better to sacrifice a small amount of cotton than to defer the operation. The loss will more than be made good by an increase in the next crop.

Some objections to the work of destroying the weevils in the fall are frequently raised. The principal one is that the labor supply is insufficient to enable planters to have the crop picked out in time for such fall destruction as is recommended.[a] One of the respects in which the boll weevil will make revolutionary changes in the system of producing cotton is that smaller areas than formerly must be cultivated by each hand. The production can best be kept up or increased by more intensive methods on smaller areas. If this principle be put in operation on plantations in so far as it is practicable, the objection to fall destruction on account of the scarcity of labor will tend to disappear. A minor objection raised is that the process tends to impoverish the soil. As a matter of fact, the burning of the stalks removes only a small amount of the fertilizing elements, and, moreover, the practice now is to burn the plants a few months later. In nost cases the humus is more important than the fertilizing elements hemselves. The use of commercial fertilizers in one case and the practice of green manuring in the other will solve both of these lifficulties.

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[a] In this connection attention is directed to one of the many advantages of having the crop picked out early. The earlier this is done the cleaner the lint will be, and the better the price. Moreover, the longer the unpicked cotton remains in the fields the greater will be the amount that falls to the ground and soon passes beyond recovery. From every standpoint the cotton should be picked as rapidly as possible.

METHODS OF DESTROYING WEEVILS IN THE FALL.

The reader is referred to Circular 95 of the Bureau of Entomology for particulars regarding methods of destroying the weevils in the fall. In this connection it will be stated that the proper method, in general, is to uproot the plants by means of plows, and to burn them as soon as possible. Other methods are applicable to different conditions. As soon as the plants are uprooted they should be placed in piles or windrows, which will utilize the leaves in the burning. The difficulty in one method of removing the plants—that of cutting them off near the surface of the ground with a stalk cutter or ax—is that during mild seasons many sprouts soon make their appearance to furnish food for weevils that would otherwise starve during the fall or winter. If the ordinary stalk cutter be followed immediately by plows, some of the desired results will be obtained. The great objection is that the innumerable weevils in the bolls and squares will be allowed to develop. Nothing but uprooting and burning will come near meeting the exigencies caused by the weevil.

Grazing.—In some cases the grazing of the fields with cattle, sheep, or goats can be practiced. This is only a local measure, however, since the supply of live stock in regions where the bulk of the cotton crop is produced is insufficient for the purpose.

Sprout cotton.—A most important result of the proper manipulation of the plants in the fall is that no stumpage or sprout cotton is allowed to grow. The occurrence of such cotton in southern Texas and occasionally in southern Louisiana is there the most important local difficulty in the control of the boll weevil. Sprout plants are sometimes encouraged on account of the production of a small but very early crop. This may have been defensible before the advent of the boll weevil, but at the present time the practice is undoubtedly the worst that could possibly be followed. The sprout plants serve only to keep alive myriads of weevils that could easily be put out of existence by the farmer.

Volunteer cotton.—In addition to stumpage cotton, volunteer cotton, in the strict sense, is of considerable importance in weevil-infested areas. The seed scattered about seed houses and gins frequently give rise to plants, both in the fall and in the spring, that furnish food and breeding places for weevils. It is needless to call attention to the fact that all such plants should be destroyed. They are merely aids to the enemy.

can be destroyed, and this is undoubtedly well
will cost. In many cases surprising numbers
found hibernating in the trash and rubbish o
fields. In January, 1907, in one instance, 5,87
found, of which 70 per cent were alive. Thi
ceptional, but most of the many examinations n
1,000 live weevils per acre in old cotton fields.
are largely at the mercy of the farmer. He
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farmer invites loss who does not clean the fi
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Of the multitudes of weevils that fly out o
hibernation not all are beyond the reach of t
to be found along turn-rows, fences, hedges, a
cleaning and burning of hedges, fence corne
removal of trash from the vicinity of fields wil
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Old sorghum fields, on account of their roug
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radiates into the field. If it were possible to eliminate the hibernating quarters across the lane—and this means only the prevention of the growth of weeds—there would evidently be a considerable reduction in weevil damage, especially early in the season when it is most critical.

LOCATING FIELDS TO AVOID WEEVIL DAMAGE.

The illustration just given emphasizes a method of averting damage by the weevil that can be followed in many individual cases. All planters that have had experience with the weevil know that the portions of their properties near the timber or other hibernating quarters show the first damage by the weevil and consequently the least production. Of course, it is not always possible to plant other crops in such situations. Nevertheless, very frequently farmers can avoid damage by devoting the particular fields known to be most susceptible to weevil injury to other crops. This is not pointed out as a general recommendation. In many cases it would be entirely impracticable, but its importance should be realized by planters in regions where every possible precaution must be taken.

CROP ROTATION.

Save in very exceptional cases the boll weevil never does as much damage on land where cotton follows some other crop as on land where cotton follows cotton. This is due to the fact, as has been pointed out, that the weevils do not fly very far from their hibernating quarters in the spring. Therefore it is evident that a proper rotation of crops may be followed to assist in the fight against the boll weevil. As in the case of the location of the fields referred to above, the recommendation here made is no panacea. Nevertheless, rotation can be made to assist in fighting the weevil, aside from the many other advantages that are known to come from it.

PROCURING AN EARLY CROP.

Although the destruction of the weevils in the fall is the great essential step in controlling the insect, it can not be depended on exclusively. The full benefits of the fall work and the maximum crop can not be obtained unless the next great step, procuring an early crop, is also taken. In fact, the success of the farmer in producing cotton in regions infested by the boll weevil will depend directly upon the extent to which he combines the various methods described in this bulletin.

There are certain localities where the conditions cause the soil to be "late" or "slow." For instance, the planters on the Red River in

Louisiana state that they can procure early crops on their "front" land, but that such is difficult or impossible on the fields back from the river. This is largely a matter of drainage. In some sections in Louisiana and Mississippi the essential step in obtaining an early crop will be largely a question of drainage. Lands so situated that they can not be drained economically to the extent that allows an early crop must be devoted to crops other than cotton.

The advantage of early planting has been demonstrated in every one of the numerous experiments made by the Bureau of Entomology and has now become the general practice among farmers. The reasons for the efficiency of early planting are not far to seek. The small numbers of weevils passing through the winter must have considerable time to multiply. They are unable to breed until squares are put on by the plants, since the food obtained from the fruit is required before reproduction can begin. Moreover, at the time the first squares are put on, the development of the immature stages is comparatively slow, not reaching the very rapid rate that obtains during the warm days and nights of the summer. For these reasons it is possible for the farmer to rush his crop in such a way that a large number of squares and bolls will be formed before the weevils have multiplied to a serious extent. Of course, under usual conditions the weevils will ultimately multiply so that the crop put on after a certain date will all be destroyed. This, however, is of no importance, since a top crop in weevil regions is entirely out of the question. The time it takes the weevils to recuperate after the vicissitudes of winter, especially after the entirely feasible destruction of multitudes in the fall, can thus be taken advantage of in the production of a crop.

Removal of plants.—The first step in the procuring of an early crop is the early removal of the plants, so that the land may be plowed during the fall or winter and the seed bed given thorough and early preparation. In fact, such preliminary preparation should be followed for the production of the best cotton crop under any conditions. The recommendation made is therefore neither onerous nor revolutionary. The tendency has often been to neglect the cotton fields until spring or at least until "after Christmas." It would repay the farmer many times if he would take the slight additional trouble of plowing the fields before that time. Not only a plowing, but one or more harrowings should be given the land during the winter.

Use of commercial fertilizers.—An important step in procuring an early crop under many conditions is the use of commercial fertilizers.

In many large areas in the cotton belt the land is not impoverished to the extent that it actually needs fertilizers under normal conditions. It has been demonstrated many times by the different experiment stations in the South that the maturity of cotton can frequently be hastened materially by the use of fertilizers, especially those containing a high percentage of phosphoric acid. The recommendation for the use of fertilizers in weevil regions, therefore, does not imply the exhaustion of the soil. It merely means that fertilizers place in the hands of the farmers an important means of averting damage by the boll weevil. The proper use of fertilizers is a very complicated matter. In fact, in the light of all present knowledge only the most general rules can be laid down. Each farmer must experiment with the soil or different soils upon his own place and study the results to obtain the greatest benefit from fertilizers at the smallest cost. In the eastern portion of the cotton belt most of the farmers have acquired this experience. In the West, however, this training is lacking. Farmers interested should communicate with the State experiment stations and obtain the latest bulletins regarding experiments with fertilizers in their own regions.

Use of early varieties of cotton.—Next in importance to early preparation, and fertilization (where necessary), in obtaining an early crop of cotton comes the use of early varieties. In all experiments that have been undertaken the advantage in the use of early varieties has been conspicuous. As in other cases, the greatest advantage in this instance comes with the joint use of the other expedients recommended for weevil control. By far the best method for obtaining seed of early maturing cotton is for the farmer to carry on the selection himself. In many cases, however, this is impracticable. Under such circumstances the farmer should obtain seed of improved varieties from dealers or such individual farmers in the locality as have been able to carry on careful seed selection. A valuable publication on the selection of cotton varieties has been published by this Department as Farmers' Bulletin No. 314, "A Method of Breeding Early Cotton to Escape Boll Weevil Damage," by R. L. Bennett. A copy may be obtained by any planter by application to the Secretary of Agriculture.

Standard early varieties of cotton.—There are a number of standard varieties that have been found of value in weevil-infested regions the seed of which may be obtained from seed dealers. Among them are the Rowden, Triumph, Cleveland Big Boll, Cook's Improved, and King. All of these except the King have either medium-sized or large bolls. The King has a small boll, about 80 being required to make a pound, but is remarkably early and has given the best yields in most of the experiments of the Bureau of Entomology.[a] Hawkins' Early Prolific and Simkins have given good results in recent experiments of the State crop pest commission of Louisiana. In all cases it will pay the planter to exercise care in obtaining seed. Wherever possible it should be obtained from the originator.

Heavy cotton seed.—The Department of Agriculture has called attention to the advantage of planting heavy cotton seed (see Farmers' Bulletin No. 285). This should be taken into consideration along with other means of obtaining an early and vigorous stand. Another recent suggestion of assistance in obtaining an early start in the spring is that the planting be facilitated by covering the seed with paste. This method will make it possible to use an ordinary corn planter in putting in cotton seed and facilitate the work of checkrowing. This matter is discussed fully in the Farmers' Bulletin just referred to.

Early planting.—Another step to be taken in obtaining an early crop, and fully as important as those that have been mentioned, is early planting itself. Naturally no set rule can be laid down as to the proper date for planting. There is much variation in the seasons, and it is sometimes impossible to place the fields in readiness as early as is desirable. Much of the effect of early planting is lost unless the seed bed is in good condition. Rather than plant abnormally early it would be better to improve the seed bed. It is not recommended that planting be made at dangerously early dates. Nevertheless, with proper preliminary attention to the fields it would be possible for farmers in most localities to plant from ten to twenty days earlier

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[a] Some of the early maturing varieties of cotton happen to have small bolls, although the plant breeders hold that there is no necessity of an early maturing cotton having small bolls. In view of the fact, however, that some of the best known early maturing varieties at the present time have undersized bolls, occasional objections have been made to planting them. It is true that the picking of cotton from these varieties sometimes involves difficulties. In some cases it is known that pickers have refused to pick small-boll cottons while any other cotton was available despite the offer of additional payment on account of slow picking in the fields of the smaller bolled cotton. This is an actual, practical difficulty that must be taken into consideration. At the present time it is sufficient to call attention to the fact that the practical disadvantage of small bolls may not be as important as appears at first glance. For instance, if small-boll varieties yield 100 pounds of seed cotton per acre more than ordinary cotton, this gain would permit the farmer to pay 10 per cent more for picking, with profit. Thus:

750 pounds small-bolled cotton per acre picked at $1 per cwt., cotton at $3 per cwt., net profit	$15.00
[illegible]0 pounds large-bolled cotton per acre picked at 90 cents per cwt., cotton sold at $3 per cwt., net profit	13.65
Difference in favor of small-boll cotton	1.35

than they are accustomed to at the present time. This, therefore, is the general recommendation that is made. It is much better to run the risk of replanting, provided the seed bed is in good condition, than to defer planting on account of the danger of cold weather. Of course it is possible to plant entirely too early, so that the plants become stunted during the early days of their growth. It is not intended that planting should be made early enough to have this effect upon the plants.

ADDITIONAL EXPEDIENTS IN HASTENING THE CROP.

It was pointed out in connection with the enemies of the boll weevil that under natural conditions a large percentage of the weevils is killed by heat and parasites. The wide spacing of the cotton plants augments the action of both these agencies working against the boll weevil. The effect of the sun heat has been studied in many cotton fields. The mortality becomes remarkably high during the hot days of summer. The farmer can take advantage of it, and even increase it. It is very conservative to state that the weevils will be able to multiply only half as fast in fields where there is plenty of distance between the plants as in fields where plants are close together and the branches cross from row to row. It should therefore be the rule of the planter in weevil regions to give considerably more distance to the plants in the drill and to the rows than he would give under ordinary conditions. On land that produces under normal conditions from 35 to 40 bushels of corn per acre the rows should be 5 feet apart. Even on poor soil it is very doubtful, except in dry regions of the West, whether the distance should ever be less than 4 feet.

Check-rowing.—Considerable attention has been attracted in some localities in Texas to the practice of check-rowing cotton to assist in the control of the weevil. Undoubtedly from this standpoint the practice is to be recommended highly. By following it each plant is given the maximum soil that it can use with consequent beneficial results upon its growth. The greatest possible amount of sunlight is allowed to fall upon the ground where the infested squares are found, to destroy many weevil larvæ outright and at the same time to facilitate the work of the numerous enemies of the weevil that occur in every cotton field. Check-rowing, moreover, saves much labor, thereby reducing the cost of production, and also makes easy the control of noxious weeds. The only important objection is that in some localities it may interfere with drainage.

Cultivation.—During the growing season of the crop the fields should be given very careful cultivations. Most of the benefits of early preparation, early planting, and fertilization may be lost in case the fields are not given the utmost attention subsequently. In case of unavoidably delayed planting the best course to pursue is to cultivate the fields in the most thorough manner possible. Under most conditions the old plantation rule "once a week and one in a row" should be made to apply. This will not result in the direct destruction of many weevils, but it causes the plants to continue uninterruptedly in their growth. By all means such operations as deep cultivation, and cultivation close to the plants, which causes shedding, should be avoided. In many instances a fair crop already set and beyond danger from the weevil has been lost by running the plows so close that the side roots were cut and the plants have shed practically all the fruit. When this happens during the middle or latter part of the season the weevils will certainly prevent the putting on of any more fruit. The general practice of laying by, by scraping the middles with a wide sweep, leaves a hard surface which causes loss of moisture and shedding. Where the weevil occurs, every precaution must be taken to avoid shedding, as the insect will certainly prevent the maturity of the later fruit and, moreover, will be forced to attack bolls which would otherwise not be injured.

Effect of late cultivation.—A very conspicuous illustration of the disastrous effects of careless late cultivation came to the attention of the Bureau of Entomology during the present season (1908). It was learned that some planters in the Red River Valley below Shreveport, La., were making fair crops (in one case 600 bales on 900 acres), while others were making very small yields as, for instance, in one case 200 bales on 800 acres. Upon investigation it was found that all the planters in the neighborhood were compelled to put all their hands on levee work for five weeks to save their places. During that time the cotton remained uncultivated. After the subsidence of the flood the fields were plowed. Where this work was done carefully the good crops were being produced. In cases where the plows were run too deeply and too close to the plants excessive shedding had taken place and the weevils prevented the putting on of any more fruit. Careful investigation on several places where the essential conditions were identical left no doubt that the cause of the difference in yields was primarily the difference in summer cultivation.

Occasionally a farmer is found who has obtained better yields on fields where cultivation has been discontinued early. In fact, the writer has seen fields full of grass that were outyielding perfectly clean ones on the same plantation. Such situations have caused erroneous conclusions. As a matter of fact, the explanation is that the late, careless cultivations had done more harm than good. The importance of careful shallow summer cultivations can not be too strongly emphasized.

SPECIAL DEVICES FOR DESTROYING WEEVILS.

The impression is more or less general that the only important way in which weevils may be killed is by the removal of the infested plants and that all other steps in the system of control are merely to avoid damage by the weevils that have survived that destruction, and their offspring. In spite of this impression, however, it is urged that the destruction of myriads of weevils can be accomplished during the growing season. This is to be done by working in cooperation with the natural agencies that destroy the weevil.

In making examinations of many thousands of infested squares from different localities and different situations in cotton fields it was found that mortality was conspicuously greatest where the sunlight was least obstructed and the heat, consequently, the greatest. The mortality in infested squares in the middles was many times as great as in the case of squares which remained under the shade of the branches. The temperature at the surface of the ground during warm days runs considerably higher than at a few feet above the surface. For instance, it was found that when the temperature was 100° F. in the regular Weather Bureau shelter about 4 feet above the ground the thermometer registered 140° F. on the surface. Likewise 90° F. in the shelter was accompanied by 120° F. on the ground and 85° F. in the shelter by 110° F. on the ground. It is not surprising, therefore, that the cotton squares that fall to the ground and are not shaded are very quickly baked, so that the weevils perish—if not from heat, then from the hardening of the food supply. In most cases they are simply roasted, their bodies assuming the appearance of larvæ that have been placed in a flame.

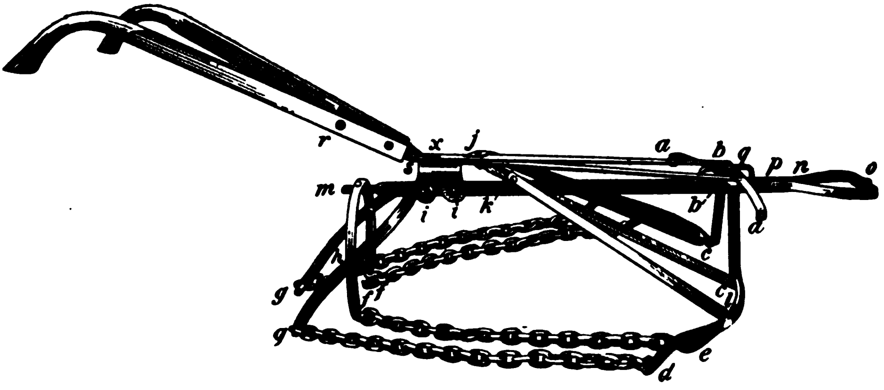


FIG. 6.—Chain cultivator, side view. (Original.)

Chain cultivator.—When the foregoing facts came to light efforts were made to perfect a device that would bring the infested squares out of the shade of the plants to the middles of the rows. After much experimental work one of the writer's former associates, Dr. W. E. Hinds, devised an implement that accomplishes the desired work in a satisfactory manner. This implement is known as the chain cultivator or chain drag.

The following specifications should enable any blacksmith to construct an effective chain cultivator. (See fig. 6.)

The draft bar (*n m*), made of $\frac{1}{2}$ by $\frac{5}{16}$ inch tire steel, about 52 inches long, is designed to be about 16 inches above the ground, and this is the height of the rear arch (*f h m*), which is of this size and form to allow old cotton roots, etc., to pass through freely without clogging at the rear.

The distance between the rear ends of the chains (*g g*, *f f*) is in each pair fixed at about 10 inches. The distance between a chain of one pair and that of the other at their front ends should be about 9 inches. The chains used are of the size known as "log chains," having short, close links of $\frac{3}{8}$-inch iron. This style of chain can be cut to the length needed in each case. The chain is easily attached by simply making the hooks at *d*, *e*, *f*, and *g* so that the end of the hook is as wide as will pass through the length of the link and narrow enough at the middle of the bend to allow the link to turn and bag the other way. So long as the chains are kept tight they can not become unhooked. The hooks should also be turned, or faced, in such a way that they will not be likely to catch the passing plants or rubbish.

The clevis (*o p*) is simply hinged, so that there will be no tendency to pull the front of the machine off of the ground, and it is also broad enough in front to allow of the point of draft being moved from one side to the other, so that the front of the machine may be thrown closer to one row if desired.

The front guard on each side (*a b c d*) is made of one piece of spring steel, $\frac{7}{8}$ by $\frac{3}{16}$ inch. This size seems sufficiently strong and best adapted to carry the tension of the chains (*d g*) while still yielding to the pressure against the bases of the plants as they may strike the outer, sloping ends near *d*. The inner ends of these guards (*a b*) are horizontal, about 18 inches each in length, and serve to carry the front guard above the draft bar (*n m*) and, passing through the keeper (*q*), guide in the adjustment for width. The machine can not be extended beyond the bent ends at *a* or closed beyond the angles at *b*. The vertical section between *b* and *c* is about 12 inches long, so that the remainder of the front guard from *c* to near *d* will be about 4 inches above the ground. This prevents the pushing of dirt and squares toward the plants and allows the chains to catch them where they lie. The hooks at *d* and *e* are therefore bent downward and somewhat backward through about 5 or 6 inches. Care must be taken especially in forming the outer ends between *c* and *d* to secure best results. The downward bend for the hook at *a* should not be abrupt, as a gradual slope helps to prevent catching on any obstacles. The hooks at *f* and *g* are formed so as to hold the chains firmly and yet not interfere with the passage of rubbish. The method of carrying the rear ends of the outer chains is shown at *i h g*. The piece *k l* is nearly parallel with the chains and may be used for their proper adjustment as to tension by several holes near the end where it is bolted at *k*. The chains are between 30 and 36 inches long. The stand *s* upon which the handles are pivoted by a ½-inch bolt is made of a piece of boiler plate bent and cut so as to have a horizontal top surface about 4 inches square and standing about 2½ inches above the draft bar, to which it is securely bolted. The handles are bolted, as at r, to the heavy pieces of iron (about 2 by ½ inch tire steel) which are bent to receive them just behind the pivotal point at *x*, at such an angle as to bring the handles to the proper height and position. In front of *x* these pieces bearing the handles need not be so heavy and may therefore be tapered and welded to smaller steel running forward to *b*, where it is bolted to the front guard. The operation of this arrangement is similar to that of a huge pair of shears—when the handles are pushed apart the front of the machine is spread wider, and vice versa. The braces *j c e* serve to support, strengthen, and carry the front guard. They are riveted to the adjusting irons at *j*, one above and one below the "shear" pieces, to prevent their interference with the closing of the machine. At *c* this iron is bent to conform to the front guard, to which it is riveted between *c* and *l*, at which point it is bent downward and forms the hook *e*. Ordinary tire steel about 1 by ¼ inch may be used for all parts like the clevis (*o p*), rear arches (*f h m* and *i h g*), and braces (*k l* and *j c e*). The front guard (*a b c d*) should be of spring steel, as specified. The rivet heads on the front guard should be round and fit smoothly. In nearly all other places the irons are fastened together by ¼-inch square-headed bolts, with washers as needed.

In operation the implement is drawn by a single animal. The chains at *d* and *e* pass under the branches of plants and close to the stems. The forward motion of the machine causes these squares to be drawn inward by the chains, which must be kept taut, and leaves them in a narrow pathway where the chains approach within a short distance of each other at the opposite end of the machine. (See figs. 7, 8.) The two chains are provided so that squares that may pass over the first are taken up by the second on either side. In actual practice it has been found that more than 90 per cent of squares may be brought to the middle of the rows. This means that the natural mortality among the weevils due to the effects of sunshine can be at least doubled.

Although the chain cultivator was designed primarily for bri the squares to the middles, it was found in field practice to h most important cultural effect. The chains (so-called " log chai are heavy enough to establish a perfect dust mulch (see figs. 7 ar and to destroy small weeds that may be starting. In fact, it is beli that this cultural effect would more than justify the use of the chine, regardless of the weevil. With the effect against the i and the important cultural effect it is believed that this implemen

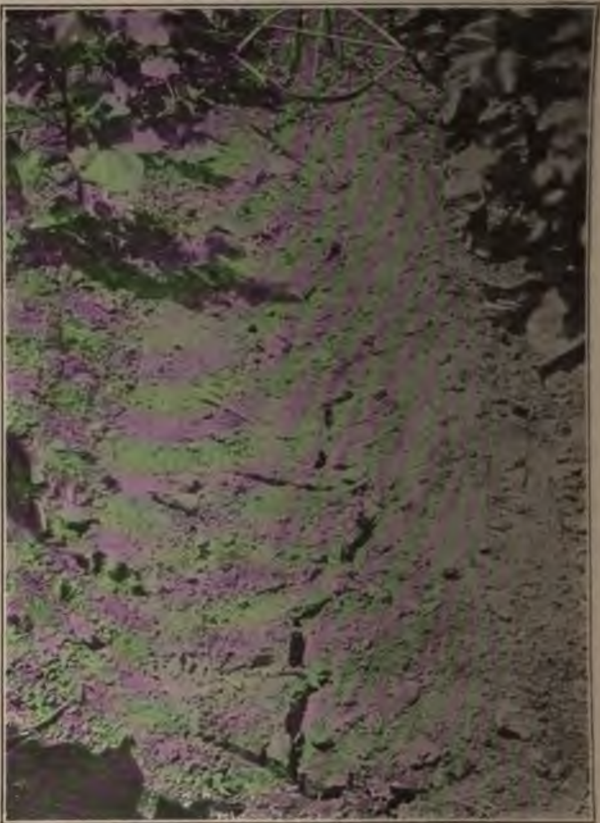
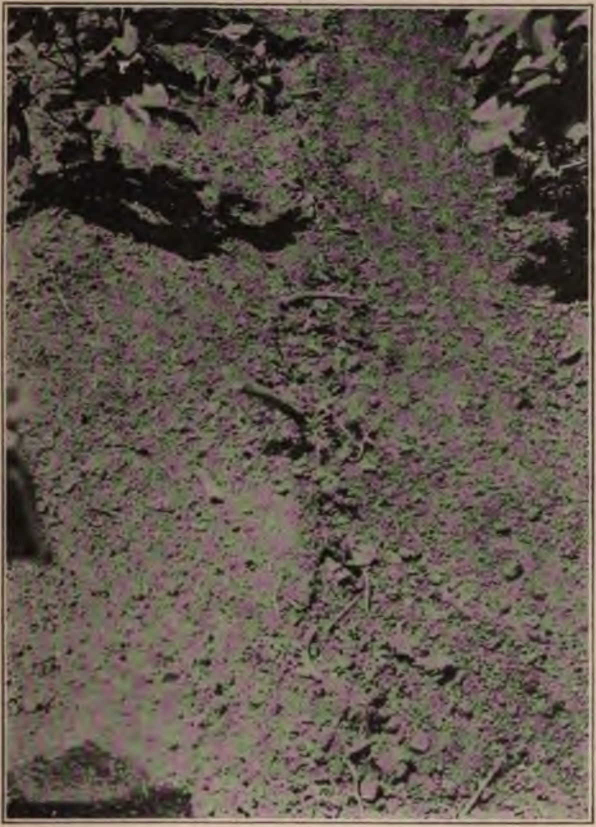


FIG. 7.—Work on the chain cultivator: Cotton row before use of cultivator, sho fallen squares, crack, and rough condition of ground. (Original.)

one similar to it should be used by every farmer in the we territory.

In order that the use of this machine could be obtained by all f ers at the smallest possible cost, a patent has been taken out in name of the Department of Agriculture and for the benefit of people of the United States. Under this patent it is impossibl anyone to manufacture the machine exclusively and to charge un essarily high prices.

Attachments for ordinary cultivators.—Some of the effects of the in cultivator may be obtained by attaching chains to ordinary tivators by the use of special attachments. In this way some of effect of the chain drag would be added to the work of the cultior. Wherever for any reason it is impossible to obtain chain gs, it is suggested that the principle be incorporated in some ple attachments to cultivators.



. 8.—Work of the chain cultivator: Same row shown in fig. 7, after cultivator has assed; majority of squares brought to middle, crack filled, and dust mulch established. Original.)

The use on ordinary cultivators of an arm or projection that will sh or agitate the plants in passing will assist to a certain extent destroying the weevil. The squares will be knocked to the ground lier than they would fall, and this would naturally increase the ect of heat. At the same time a very few adult weevils will be cked to the ground, but this has been found to be unimportant. repeated experiments in jarring and beating cotton plants on ich known numbers of weevils were found it was ascertained that very few, if any, left the plants by reason of any agitation that would not break the branches or bark the stems. Occasionally, however, a weevil passing over a leaf is jarred to the ground. Often entirely too much stress is placed upon the importance of jarring the adult weevils to the ground. When specimens are collected by hand and thrown on the surface of the ground, especially if it be finely pulverized, the great majority will be killed almost instantly by the heat. This has caused the mistake on the part of careless observers of supposing that many weevils could be killed by jarring them to the ground. The difficulty, as pointed out, is that it is totally out of the question to jar more than one weevil out of many hundreds to the ground by any process that would not injure the plants severely. Nevertheless, the effect of a cross-arm of wood or iron whipping through the tops of the plants is recommended for the reason that the squares are thrown to the ground, where the heat has its earliest possible effect upon them.

HAND PICKING OF WEEVILS.

Gathering the weevils by hand is an operation of limited applicability. Where the fields of cotton are small and there is an abundance of labor it is sometimes practicable to pick the early emerging weevils from the plants and later to pick up the early fallen squares. Everything depends, however, on the conditions being favorable. On large places it will undoubtedly not often be found practicable to carry on this process. In an experiment performed by the Bureau of Entomology on a plantation worked by convict labor, giving the optimum conditions for the experiment, no results whatever followed thorough pickings twice each week for two months in the spring, beginning with the appearance of the first weevils. In another instance, at Gurley, Tex., more than 40,000 weevils were picked on an area of 8 acres by means of paid labor, beginning in April and continuing until July. On the 8 acres where this work was done a crop of about 50 pounds per acre in excess of that on other areas was obtained. This was not sufficient, however, to pay for more than a very small fraction of the work done. From these and other experiments the Bureau of Entomology recommends in a guarded manner the picking by hand of weevils and squares. Undoubtedly good may be accomplished under certain conditions, but planters should be careful not to depend too much upon it and not to make too great an outlay for it.

Disposition of adult weevils and infested squares.—When adult weevils are picked by hand they should be killed by means of oil or fire, or buried deeply in the ground. When infested squares are picked, however, an entirely different procedure should be followed. Many of the weevil larvæ in the infested squares will be found to harbor parasites. It is entirely practical, as has been pointed out by Mr. Wilmon Newell, of the Louisiana crop pest commission, to let these parasites develop and continue their work against the weevils in the fields. This is done simply by placing the infested squares in wire cages. The parasites, on account of their small size, will escape, while the weevils soon die from a lack of food. The meshes of the wire of the cage should be at least 16 to the inch. However, some weevils will escape through this mesh, and about 5 per cent through a 14-mesh screen. Even if the finer wire can not be obtained, it is advisable to use what can be had. A calculation will show that there is a direct advantage even if a few of the weevils escape, if all of the parasites do. By burning or destroying the squares in any other way the farmer is simply working against and counteracting an agency in the control of the weevil that is much more important than any amount of hand picking he is likely to be able to do.

TOPPING OF PLANTS.

The practice of topping plants is sometimes recommended for fields infested by the boll weevil. The results of work by different experiment stations have shown that topping has exceedingly uncertain general results. As often as otherwise it decreased instead of increased the crop. In any case the topping of plants can probably do no harm in fields that are being damaged by the weevil. It is probable that the general results will be beneficial in causing the more rapid growth of the crop on the lower and middle branches. It has never been possible to demonstrate this in an exact way. Nevertheless, for the general effects stated the topping of plants is included among the recommendations that should be followed, although as one of minor importance.

COTTON LEAF-WORM AND BOLL WEEVIL.

The relation between the formerly dreaded leaf-worm or so-called "army-worm" and the boll weevil deserves special attention. A quarter of a century ago the efforts of entomologists and planters were directed toward some means of destroying the leaf-worm. The use of Paris green was found to be effective. Various changes in the general system of cropping cotton also caused the injuries of the leaf-worm to become less conspicuous year after year. Even up to the time of the spread of the weevil into Texas, however, poisoning was a more or less regular operation on all cotton farms. The insects never did any considerable damage before the middle or latter part of the season. The object in destroying the leaf-worm was that it prevented the maturity of a fall crop. For this reason the saving of the top crop and in exceptional seasons a part of the middle crop was all that was desired. The work of the boll weevil has changed all this. After the careful studies that have been given the problem it is evident that no top crop of cotton can be expected in infested regions. This, of course, reduces the leaf-worm to an insect of no importance where the boll weevil exists.

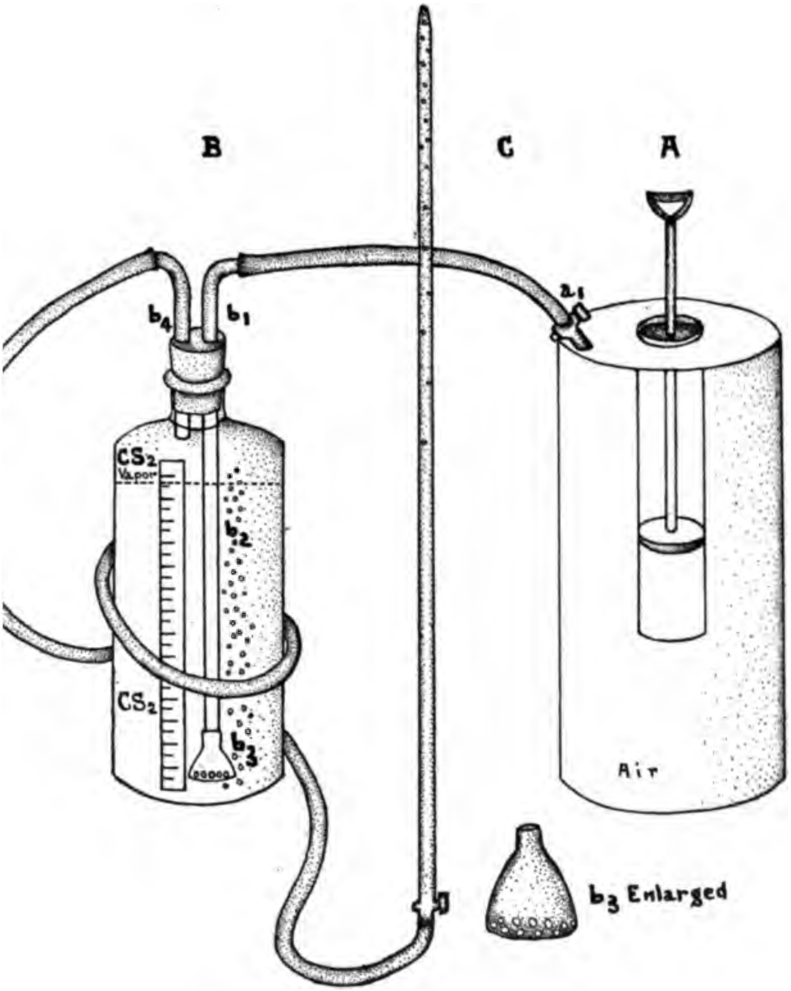
The change has actually been even greater than this, for the work of the leaf-worm has a disastrous effect upon the boll weevil. As has been pointed out in the discussion of fall destruction, the late developing weevils are the ones that pass through the winter. Consequently, if the leaf-worms defoliate the plants and stop the formation of squares, a certain degree of fall destruction is accomplished. It can never be as satisfactory as the poorest artificial fall destruction, because the plants continue to leaf out after the defoliation by the worms, thus giving the weevils a supply of succulent food. It is not recommended that the work of the leaf-worm be depended on in place of fall destruction. Nevertheless, allowing the leaf-worms to proceed with their work, or even encouraging them, will assist as a general procedure against the boll weevil at least when, for any reasons, the more important steps are not taken. In some cases where the injury by the leaf-worms begins unusually early, it may still be advisable to check it by poisoning in the well-known manner, but save in such exceptional circumstances it will now be better to allow the leaf-worm to work unrestrictedly.

It has been suggested by Mr. Wilmon Newell that in special cases where there are difficulties in the following of the fall destruction of the plants, it may be advisable to take means to encourage the leaf worm. This could be done by breeding larvæ and pupæ to be scattered in the fields and by carrying the pupæ from localities, as the hills, where they appear first, to the valley fields, which are normally not reached until some time later.

DESTROYING THE WEEVIL IN COTTON SEED.

It has been abundantly shown that cotton seed is of importance as a medium through which the weevil may be carried. Many individuals that happen to be carried to the gin on the cotton pass uninjured through the gins to the seed houses. Consequently every seed house connected with a gin in the infested territory harbors more or less weevils, depending upon the amount of cleaning the staple is given. Of course such seed is exceedingly dangerous when taken into uninfested regions. Undoubtedly the present absolute embargoes against cotton seed from the infested region are wise. In general they should be strictly construed. In some special cases, however, when, for instance, it is desired to obtain special improved seed, er precaution can be taken to destroy all weevils by means of gation with carbon bisulphid. The method was described by the r in Farmers' Bulletin 209, from which the following is quoted:

> following plan for this work is proposed: A tight matched-board box l be provided having sides 4 feet high, open on top, and of other dimen- to accommodate 12 or more 100-pound sacks of cotton seed placed upright the bottom. Another tier of sacks could be added if desired. Into each f these sacks about 1 ounce of carbon bisulphid should be forced by an atus for volatilizing the liquid and mixing the vapor with air. The ac- nying illustration (fig. 9) will give an idea of this apparatus. It should t of three essential parts, as shown in the illustration. A is an air pump g sufficient storage capacity to enable it to maintain a steady discharge of



9.--Apparatus for fumigating cotton seed in the sack. (Author's illustration.)

air for several minutes without continuous pumping. The stopcock at a_1 regulates or prevents the escape of air, as may be desired. *B* is an ordinary 2-quart bottle fitted at b_1 with a tight stopper of good length, having two openings, through which the inlet and outlet pipes pass. These pipes may be of glass or metal and should be as large as can be used. The inlet pipe, b_2, reaches nearly to the bottom of the bottle and is provided at the lower end with a perforated metal cap as large as will pass through the neck of the bottle. This allows the escape of the air in small bubbles and insures rapid evaporation. The outlet pipe, b_3, reaches only through the stopper. Upon the outside of the bottle is pasted a paper marked with 1-ounce graduations. *C* is a piece of ordinary ⅜-inch iron gas pipe about 3½ feet long, but this may be any desired length. It is closed and roundly pointed at the tip, and for about 15 to 18 inches of its length provided with small perforations pointing in all directions to give free escape to the vapor into all parts of the sack of seed at once.

The connections may be of rubber tubing, but as little rubber as possible should be used for this apparatus, as it is affected by the vapor of the bisulphid, and the couplings will have to be frequently replaced. This, however, will not be a considerable item of expense. With the apparatus just described one operator would be able to accomplish the entire work of disinfection. The amount of carbon bisulphid recommended is about 1 ounce for each 3-bushel sack. It is safe to say that this can be secured for less than 1 cent per ounce when purchased in 25 or 50 pound lots, making the cost of bisulphid not over 1 cent per sack. As it requires but from two to three minutes to vaporize 1 ounce of the liquid in the manner described, the expense for labor in application would not amount to one-half a cent per sack. Fumigation with carbon bisulphid can therefore be effectively made at the slight expense of from 1 to 1½ cents per 100-pound sack.

Application of the bisulphid in this manner reduces the elements of danger to a minimum, as the vapor is almost wholly confined and the slight quantity escaping, mixed with the open air, would not be in either inflammable or explosive proportions. It has been determined that the slight trace of bisulphid vapor in the air would not injure the operator in the slightest degree. The sacks should be left in the box for forty hours after the gas is injected.

RELATION OF MEANS OF CONTROLLING THE BOLL WEEVIL TO THE CONTROL OF OTHER INSECTS.

The cotton bollworm.—The most important insect enemy of cotton in the United States, aside from the boll weevil, is the bollworm. This pest has existed in this country for many years and frequently reduces the crop very considerably. The annual damage to cotton in the United States has been conservatively estimated at over $8,000,000. In addition to the injury to cotton this insect is a very important enemy of corn, tomato, okra, cowpeas, and some other crops. Careful studies of the bollworm were conducted by Mr. A. L. Quaintance, of the Bureau of Entomology, in connection with large-scale field experiments in many localities. The conclusions drawn from this practical work were that the essential steps to be resorted to in the control of the boll weevil are exactly the ones that should e followed in the warfare against the bollworm. The following is he statement by Mr. Quaintance on this subject:

> The steps in the production of early cotton, outlined above, include the prin-ipal recommendations for the growing of cotton in the presence of boll weevils. t is therefore seen that injury from the cotton bollworm and the cotton boll eevil may be best avoided by the adoption of one and the same course of mproved farm practice. The spread of the latter species will render impera-ive the adoption of these methods in profitable cotton culture, and along with his change the ravages of the bollworm during normal seasons should become ess and less.

The cotton aphis.—Of the numerous minor enemies of the cotton plant in the United States there is one, the cotton aphis, or plant-louse, that may occasionally cause unusual damage by reason of early planting. This will only happen to any appreciable extent during wet seasons. Under such conditions the aphis may sometimes make it necessary to replant.[a] Nevertheless, this is not an important difficulty. It is not of sufficient moment to be considered at all, in view of the enormous benefit in avoiding damage by the boll weevil by means of early planting. If the other steps in the control of the boll weevil be taken and the fields made clean during he winter and the rubbish in the fence corners and along the turnrows destroyed, it is not likely that the aphis will do any considerable damage, even during the coolest and wettest springs.

The injury inflicted by several other insects, such as the cotton quare borer, webworm, and cutworms often makes the crop somewhat later, and consequently likely to be injured by the weevil.

GENERAL CONTROL THROUGH QUARANTINES.

There is no doubt whatever that the weevil can not be prevented rom extending its range to the extremes of the cotton belt in this ountry. However, the damage is so great and the disturbance of conomic conditions so extensive that all reasonable precautions hould be taken to prevent the early accidental importation of the weevil to uninfested regions. Practically all of the States in the cotton belt have enactments designed to this end. Undoubtedly hey should be enforced to the fullest extent.

At one time considerable inconvenience was caused the shipping nterests by the lack of uniformity of quarantines in different tates and the inclusion of articles in which there is very little danger. At the present time these difficulties have largely been removed. All that it is advisable to include in the absolute quarantines are cotton seed, seed cotton, cotton-seed hulls, and baled cotton. These commodities are likely to carry the weevil with them. In fact, it has been amply demonstrated that the insects are frequently carried in this way. Other articles, and even empty cars, may occasionally transport weevils, but the degree of danger is so much less than in the cases of the articles specified above that they do not need to be taken into consideration.

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[a] On the contrary, cases have been noticed where early breaking and thorough orking caused a lessening in the number of aphides, due to the destruction f the ant that protects them. Mr. Wilmon Newell calls our attention to an nstance of this kind in Louisiana in 1908.

It is entirely feasible to eradicate small isolated colonies of the boll weevil. An important office of the State authorities, concerned in State quarantines should therefore be to investigate reported outbreaks of the weevil and be prepared to take the necessary steps toward eradication at the earliest moment. The Bureau of Entomology will assist the state authorities in any cases of this kind.

ATTEMPTS TO POISON THE BOLL WEEVIL.

From the very beginning of the fight against the boll weevil attempts have been made to poison it. In 1894 and 1895, in the region originally infested in Texas, agents of the Bureau of Entomology conducted careful experiments with poison. Since that time various advocates of poisons have appeared. The idea appeals so strongly to farmers that these advocates have sometimes enlisted considerable followings. This has made it necessary for the Bureau of Entomology to carry on a large number of special investigations relating to poisons. In order to understand the difficulty of poisoning it must be remembered that during the growing season the boll weevil feeds only by inserting its beak deeply into the squares or bolls. It is therefore entirely out of the question to place the poison in a position where the insect will feed upon it.

Early in the season, however, before any squares are formed, the hibernated weevils that may have emerged feed upon the opening leaves on the so-called bud of the young cotton plant. At this time it is possible to destroy a considerable percentage by the application of poison. In all experiments performed in the field by the Bureau of Entomology very heavy applications throughout the season from chopping to picking have failed to show any advantage in the use of poison. Even light applications have been found to have insidious injurious effects upon the plants. The reason for the ineffectiveness of poisons is that the great majority of the weevils do not emerge from hibernating quarters until after the squares have begun to be formed. The destruction of some of the early emerging individuals does not prevent the remainder from causing complete infestation of the fields at the usual time.

Arsenate of lead.—Recently Mr. Wilmon Newell, of the State crop pest commission of Louisiana, has published a preliminary report regarding experiments with powdered arsenate of lead as a poison for the boll weevil. This substance has the advantage of being absolutely harmless to the plants, whereas Paris green applied to the tender terminal growth frequently causes the plants to become stunted, to remain so throughout their lives. Although the powdered arsenate of lead has this advantage, the question still remains as to whether enough weevils can be poisoned to result in any special benefit to the crop. The following is Mr. Newell's statement on this subject:

> As it is, the profit to be derived from applying the powdered arsenate of lead when the cotton is in the budding stage can only be determined by actual tests in the field, in which the production of poisoned and nonpoisoned cotton (both under conditions otherwise exactly alike) is carefully determined.

It will be noted from Mr. Newell's statement that no field experiments have been carried on to determine whether any direct benefit can be obtained from the use of powdered arsenate of lead. The Bureau of Entomology therefore urges that until further notice no farmers go to the expense of attempting to poison the boll weevil in any way.

Many attempts have been made to cause poisoned substances to be attractive to the weevil by introducing sweets and other ingredients. All these have failed completely. Some known sweets, such as honey, have a slight attraction for the weevil, but not enough to assist in practical control even regardless of their expense.

Contact poisons.—Poisons designed to kill the weevil by suffocating rather than by being taken into the digestive organs, have been proposed. They can not, of course, be effective against the immature weevils within the cotton fruit. The difficulties in reaching the adults are in their manner of work. Normally these insects are found inside the bracts of the squares, where they can not be reached by sprays. In fact, nature designed the bracts to prevent the heaviest rains from reaching the square within. An additional difficulty is in the expense of applying sprays, not only on account of labor, but on account of the special machinery that is necessary. Although there is some very remote possibility that dry poisons may be found of assistance in controlling the weevil, on account of the facts mentioned it is not at all probable that liquid sprays can ever be used.

Effect of confinement.—There is one peculiarity of the weevil that has led to many unwarranted claims as to the efficacy of remedies. The insect will die within a very short time when confined in a bottle or jar or even in a cage. Even when cages are placed over growing plants it is found that numbers of the insects die and fall to the ground, though no poison has been applied. In many instances experimenters have applied their preparations under such conditions and have found dead weevils later. They have made no allowance for the weevils that would have died under these conditions without any treatment whatever. In such experimental work special pains should always be taken to provide one or more careful checks upon the weevils that have been subjected to treatment.

FALSE REMEDIES.

The extreme seriousness of the boll-weevil problem has called forth many hundreds of suggestions in control. These have covered such methods as changes in manner of planting, attracting the insects to food plants or lights, soaking the seeds to make the plants distasteful, sprays, machines, smokes, and the planting of various plants supposed to be repellent. In many cases these suggestions have been made without due understanding of the habits of the weevil. In other cases practical features, such as the cost of application, have not been considered. The following paragraphs deal with some of the principal fallacious methods that have been proposed.

Late planting.—Foremost among the futile means of control is late planting. At various times different persons have suggested that late planting, especially if following early fall destruction, would so lengthen the hibernating period that no weevils would be permitted to survive. Very numerous experiments in the field and in cages have proved that the weevils in considerable numbers are able to survive from any reasonable time of early destruction in the fall to beyond the date in the spring when any return whatever could be expected from planting cotton, even if the weevils were entirely eliminated. In a field experiment performed in Kerr County, Tex., the plants were removed very thoroughly early in November. No stumpage or volunteer plants were allowed to grow during the winter. There was no other cotton planted within 9 miles. On the experimental field planting was deferred until June 10. In spite of this fact weevils appeared as soon as the plants were up and multiplied so rapidly that the production was not sufficient to warrant picking. A similar experiment was carried out under different conditions by the State crop pest commission of Louisiana and the results published in Bulletin 92 of the Louisiana Experiment Station. The results obtained in Louisiana agree in every way with those obtained by the Bureau of Entomology in Texas.

The reasons for the failure of late planting are evident from a study of the habits of the insect. In many cage experiments it has been found that the last emerging weevils in the spring appear well into the month of June. In fact, emergence has taken place as late as the 27th and 28th of June. Without any food whatever the emerging weevils are able to survive for some time. The maximum known survival of any hibernated weevil without any food whatever after emergence was 90 days and a considerable number lived from between 6 to 12 weeks after emergence. This ability to survive without food, together with the late emergence, render it entirely out of the question to exterminate the boll weevil by late planting. Moreover, there are always to be found along roads, turn-rows, in cotton fields, and elsewhere, a considerable number of volunteer plants which come from seed scattered accidentally or blown from the bolls during the fall. These plants, starting early in the spring in such numbers as to be beyond control, would furnish a means for the weevils to subsist to the time of planting, regardless of how late it might be. In 1906, for instance, at Dallas, Tex., it was found that volunteer plants appeared in the spring at the rate of about 1,000 per acre. An investigation showed that the number of such plants increases to the westward as the climate becomes drier. Nevertheless, numbers of plants were found near Memphis, Tenn., and Vicksburg, Miss., in a region of more than 50 inches of annual precipitation.

Trap-rows.—The idea of attracting weevils to a few early plants or trap-rows seemed hopeful at one time. Practical work in the field, however, has shown that nothing whatever can be expected from this means. The difficulty is that the early plants exert very little attraction. Moreover, before the majority of the weevils have emerged from hibernation the planted cotton is always large enough to furnish them plenty of food. In practice it has been found impossible to defer planting long enough to concentrate any appreciable number of weevils on the trap plants. Trapping weevils to hibernating quarters is an equally mistaken idea. They can not be induced to resort to any particular places. It is likewise impossible to attempt to make the cotton fields more favorable for hibernation than places outside of the field.

There is one way in which trapping may occasionally be resorted to with good effect. When the plants are destroyed in the fall and the weather is so warm that the majority of weevils have not entered hibernation, many of them will be found upon the plants that are left. Under these conditions the farmer can leave a few trap-rows to good advantage. They should be uprooted and burned within ten days of the time the other plants are destroyed, to kill the weevils that may be found upon them. Hand picking at frequent intervals before destruction may be practicable where labor is inexpensive.

Attraction to lights.—Many insects more or less resembling the boll weevil are attracted to lights. This has caused many persons to attempt to destroy the cotton pest by taking advantage of the supposed habit. It has been found, however, that the boll weevil is not attracted to lights to any extent whatever. In one experiment a number of strong lanterns were placed in cotton fields in Victoria County, Tex. In all, 24,492 specimens of insects were captured, representing about 328 species. Of these, 13,113 specimens belong to injurious species, 8,262 to beneficial species, and 3,111 were of a neutral character. Not a single boll weevil was found among all these specimens, notwithstanding the fact that the lights were placed in the midst of fields where there were millions of these insects.

Chemical treatment of seed.—It is scarcely necessary to call attention to the fallacy of attempting to destroy the boll weevil by soaking the seed in chemicals in a hope of making the plants that are to grow from them distasteful or poisonous to the insect. Any money expended by the farmer in following this absurd practice is entirely wasted.

Other proposed remedies.—Many remedies for the destruction of the weevil, consisting of sprays, poisons, and fumigants or "smokes," have been proposed. Hundreds of these proposed remedies have been carefully investigated. The claims of their advocates in practically all cases are based upon faulty observations or careless experiments. The strong tendency of the weevil to die in confinement, which has been referred to, has caused many honest persons to suppose that the substances they are applying have killed it. Moreover, an insuperable difficulty that these special preparations have encountered is the impracticability of the application in the field. Hundreds of known substances will kill the weevil when brought in contact with it. The difficulty is to apply them in an economical way in the field. A striking instance of the unwarranted claims of some discoverers of "remedies" for the weevil was the case of a man who demonstrated the efficacy of his preparation by placing a feather in the bottle containing it and applying this to a weevil in his hand. Of course the death of the weevil was very far from a demonstration of the practical working of the supposed remedy. On account of the many difficulties in reaching the weevil and the necessity of obtaining special machinery for applications of poisons or sprays in the field, it is now considered, after much careful experimentation, that there is only the remotest hope of any such substances being of any practical avail whatever in the fight against the boll weevil. The claims made at different times of the repellent power of tobacco, castor-bean plants, and pepper plants against the boll weevil have no foundation whatever. In fact, none of these plants has the least effect in keeping weevils away from cotton.

Mechanical devices.—Many machines have been constructed to collect the weevils from the plants, or the bolls and squares from the ground. These have consisted of suction and jarring devices. Many of them will destroy a certain number of weevils, but the habits of the insect are such that none has been found to yield results that pay even a small portion of the cost of operation. It is emphasized in this connection that there are plenty of proper ways in which all available mechanical ingenuity may be utilized in the fight against the weevil. There is great need for effective machines for assisting in the destruction of the weevils in the fall, and also for assistance in the cultivation of the crop. The present implements for cultivation, while effective in their way, could be improved in many respects, especially for the purpose of hastening the maturity of the crop. For instance, cultivators like the chain-cultivator mentioned in this bulletin, to establish a dust mulch rather than to plow the ground, are much needed. There are some cultivator attachments, such as the spring-tooth attachment, which are exceedingly useful tools in maintaining a surface dust mulch, but these are not as yet in general use.

SUMMARY.

The following is an outline of the practical methods of controlling the boll weevil described in detail in the preceding pages. These methods are based upon extensive studies and much field experimentation. They represent practically all that is known about combating the most important enemy of the cotton plant. They form a system consisting of several parts. The planter can insure success in proportion to the extent to which he combines the different essential parts.

(1) Destroy the vast majority of weevils in the fall by uprooting and burning the plants. This is the all-important step. It results in the death of millions of weevils. It insures a crop for the following season.

(2) Destroy also many weevils that have survived the preceding operation and are found in the cotton fields and along the hedgerows, fences, and buildings. This is done by clearing the places referred to thoroughly. (See pp. 22–23.)

(3) As far as possible, locate the fields in situations where damage will be avoided. This can not be done in all cases but can frequently be done to good advantage.

(4) Prepare the land early and thoroughly in order to obtain an early crop. This means fall plowing and winter working of the land.

(5) Provide wide rows, and plenty of space between the rows and the plants in the drill, for the assistance of the natural enemies of the weevil, which do more against the pest than the farmer can do himself by any known means. Check-rowing, wherever practicable, is an excellent practice.

(6) Insure an early crop by early planting of early-maturing varieties, and by fertilizing where necessary.

(7) Continue the procuring of an early crop by early chopping to a stand and early and frequent cultivation. Do not lose the fruit the plants have set by cultivation too deep or too close to the rows.

(8) Where the labor is sufficient, pick the first-appearing weevils and the first-infested squares. Do not destroy the squares but place them in screened cages. By this means the escape of the weevils will be prevented, while the parasites will be able to escape to continue their assistance on the side of the farmer. (See pp. 34–35.)

(9) Use a crossbar of iron or wood, or some similar device, to cause the infested squares to fall early to the ground, so that they will be exposed to the important effects of heat and parasites.

(10) Do not poison for the leaf-worm unless its work begins at an abnormally early date in the summer.

(11) Do not go to the expense of buying special preparations for destroying the weevil. Disappointment and loss is certain to follow. In case of doubt communicate at once with the Bureau of Entomology or with the entomologist of the State experiment station.

SPECIAL TREATMENT OF SMALL AREAS.

In some cases, where, for instance, a farmer has a small area of cotton growing for seed selection, it is practicable to resort to special means of control that would be impossible in general field practice. For the benefit of the many farmers in the infested area who are beginning to improve their cotton by selection, the following suggestions are made: The plat or plats should be far from timber, hedgerows, seed storage houses, and other protection for hibernating weevils. On the appearance of the earliest weevils the plats should be carefully picked over by hand. This should be continued until well after the squares begin to fall. If the falling of the squares continues it will be found practicable to rake them by hand to the middles or entirely outside of the plats to a bare place, where the sun will soon destroy the larvæ within. Of course all other general suggestions that are applicable in the field should be added to these special ones.

FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to your Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

22. The Feeding of Farm Animals. PPp. 40.
24. Hog Cholera and Swine Plague. Pp. 16.
27. Flax for Seed and Fiber. Pp. 16.
28. Weeds: And How to Kill Them. Pp. 30.
30. Grape Diseases on the Pacific Coast. Pp. 15.
32. Silos and Silage. Pp. 30.
33. Peach Growing for Market. Pp. 24.
34. Meats: Composition and Cooking. Pp. 31.
35. Potato Culture. Pp. 24.
36. Cotton Seed and Its Products. Pp. 16.
42. Facts About Milk. Pp. 32.
44. Commercial Fertilizers. Pp. 38.
47. Insects Affecting the Cotton Plant. Pp. 32.
48. The Manuring of Cotton. Pp. 16.
49. Sheep Feeding. Pp. 24.
51. Standard Varieties of Chickens. Pp. 48.
52. The Sugar Beet. Pp. 48.
54. Some Common Birds. Pp. 48.
55. The Dairy Herd. Pp. 30.
56. Experiment Station Work—I. Pp. 30.
58. The Soy Bean as a Forage Crop. Pp. 24.
59. Bee Keeping. Pp. 48.
60. Methods of Curing Tobacco. Pp. 24.
61. Asparagus Culture. Pp. 40.
62. Marketing Farm Produce. Pp. 31.
63. Care of Milk on the Farm. Pp. 40.
64. Ducks and Geese. Pp. 55.
65. Experiment Station Work—II. Pp. 32.
66. Meadows and Pastures. Pp. 30.
69. Experiment Station Work—III. Pp. 32.
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73. Experiment Station Work—IV. Pp. 32.
74. Milk as Food. Pp. 39.
77. The Liming of Soils. Pp. 24.
78. Experiment Station Work—V. Pp. 32.
79. Experiment Station Work—VI. Pp. 27.
80. The Peach Twig-Borer. Pp. 16.
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82. The Culture of Tobacco. Pp. 22.
83. Tobacco Soils. Pp. 23.
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85. Fish as Food. Pp. 32.
86. Thirty Poisonous Plants. Pp. 32.
87. Experiment Station Work—VIII. Pp. 32.
88. Alkali Lands. Pp. 23.
91. Potato Diseases and Treatment. Pp. 15.
92. Experiment Station Work—IX. Pp. 30.
93. Sugar as Food. Pp. 31.
96. Raising Sheep for Mutton. Pp. 48.
97. Experiment Station Work—X. Pp. 32.
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100. Hog Raising in the South. Pp. 40.
101. Millets. Pp. 30.
102. Southern Forage Plants. Pp. 48.
103. Experiment Station Work—XI. Pp. 30.
104. Notes on Frost. Pp. 24.
105. Experiment Station Work—XII. Pp. 32.
106. Breeds of Dairy Cattle. Pp. 48.
107. Experiment Station Work—XIII. Pp. 32.
110. Rice Culture in the United States. Pp. 28.
112. Bread and Bread Making. Pp. 40.
113. The Apple and How to Grow It. Pp. 32.
114. Experiment Station Work—XIV. Pp. 28.
116. Irrigation in Fruit Growing. Pp. 48.
118. Grape Growing in the South. Pp. 32.
119. Experiment Station Work—XV. Pp. 30.
120. Insects Affecting Tobacco. Pp. 32.
121. Beans, Peas, and Other Legumes as Food. Pp. 38.
122. Experiment Station Work—XVI. Pp. 32.
124. Experiment Station Work—XVII. Pp. 32.
125. Protection of Food Products from Injurious Temperatures. Pp. 24.
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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 345.

2

ME COMMON DISINFECTANTS.

BY

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Chief of the Biochemic Division, Bureau of Animal Industry.

WASHINGTON:
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1908.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., December 2, 1908.

Sir: I have the honor to transmit herewith the manuscript of an article entitled "Some Common Disinfectants," and to recommend the publication of the same as a Farmers' Bulletin.

Very respectfully,

A. D. Melvin,
Chief of the Bureau of Animal Industry.

Hon. James Wilson,
Secretary of Agriculture.

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SOME COMMON DISINFECTANTS.

INTRODUCTION.

There is much popular misconception as to the value and limi- :ions of the various disinfectants which are sold in this country. ›r this reason the following very brief description of some of the ›re common of them has been prepared. Full and complete scriptions of these substances may be found in the very excellent ›atises of Rosenau,[a] Rideal,[b] and others.

FORMALDEHYDE.

Formaldehyde—formic aldehyde—is available on the market as raform (a sort of condensed formaldehyde, which is sold as a white wder or in the form of pastils) and also in aqueous solution gener- y known under the name of formalin. The solution is supposed to ıtain 40 per cent of formaldehyde, though in reality the amount of :maldehyde present rarely exceeds 37 to 38 per cent. Formalde- de may be used for disinfection in either a liquid or gaseous form.

LIQUID FORMALDEHYDE.

Solutions of formaldehyde are best prepared by making a 5 per ıt solution of formalin in water. This is applied directly to sub- nces that require disinfection, and in the case of refuse, excreta, and ıilar substances should be thoroughly mixed with them. A 5 per ıt solution of formalin is generally regarded as superior to car- ic acid of the same strength as a general disinfectant.

GASEOUS FORMALDEHYDE.

n disinfecting with formaldehyde gas it is essential that the com- tments to be disinfected be tightly closed so that a sufficient con- tration of the gas may be held in contact with the infected sub- nces a sufficient length of time. The temperature of the air is an important factor in securing efficient action, the formaldehyde being much more energetic in a warm atmosphere than in a cold. The best authorities state that gaseous formaldehyde disinfection should not be attempted if the temperature of the air is below 50° F. The gas is most conveniently secured by liberating it from the concentrated aqueous 40 per cent solution or from the solid paraform. A number of methods for accomplishing this in practice have been devised, the more important of these being as follows:

---

[a] Disinfection and Disinfectants. Philadelphia, 1902.

[b] Disinfection and the Preservation of Food. New York, 1903.

PRODUCTION OF THE GAS FROM FORMALIN.

Heating under pressure.—Portable autoclaves specially designed for the purpose are charged with a sufficient amount of formalin, the quantity depending upon the cubic air space to be disinfected. The autoclave is closed and heat is applied until the required pressure within the autoclave is attained. The gas which has been liberated from the solution by the heat is allowed to flow through an outlet tube into the closed chamber which is to be disinfected. The room is then kept closed for from two to twelve hours; the shorter time if only smooth surfaces are to be acted upon; the longer if penetration into fabrics is desired. Ten ounces of formalin should be used for each 1,000 cubic feet of air space.

Heating without pressure.—This method is similar to that just described. Formalin is placed in a specially designed retort and heated with a lamp. The gas is conducted into the compartment to be disinfected by means of a small tube which passes through the keyhole, or other small aperture. Ten ounces of formalin is required for each 1,000 cubic feet of space. The evolution of gas by this method is less rapid than when generated under pressure and a longer time is required for disinfection. The compartment should remain closed for at least six hours, and for twelve hours if penetration into the interior of fabrics, hay, etc., is required.

Spraying.—In this method the formalin is sprayed upon the surface of objects which require disinfection or upon sheets which are hung up in the compartment containing the infected materials. The gas is liberated by simple evaporation, this liberation being favored by the wide surface which is exposed. The gas is liberated much more slowly by this method than by either of those already described, and the diffusion is also relatively much slower. For these reasons the compartment to be disinfected should not be very large, and should remain closed for at least twenty-four hours. Not less than 10 ounces of formalin should be used for each 1,000 cubic feet of space.

Liberation of the gas by chemical means.—Several methods of liberating formaldehyde from formalin solutions without the use of artificial heat have been proposed in recent years. The most important of these is known as the " permanganate method." Formalin is poured upon crystallized or powdered potassium permanganate. A violent chemical reaction takes place immediately, heat is generated, and a rapid liberation of formaldehyde gas takes place. As will be understood, the heat is caused by the reaction between the formaldehyde in solution and the permanganate, a large portion of the formaldehyde being consumed by the reaction. The amount of gas evolved depends in great measure upon the relative weights of permanganate and formalin employed. Experiments have shown that when the formalin and permanganate are mixed in the proportion of 6 parts of formalin to 5 parts of chemically pure permanganate, by weight, 50 per cent of the formaldehyde employed is liberated in the form of gas. If 10 ounces of formalin are required for disinfection of 1,000 cubic feet of space by the first three methods described, twice that amount is necessary when the permanganate method is employed, as half of the formaldehyde is destroyed by the reaction. For disinfecting 1,000 cubic feet, therefore, use 20 ounces of formalin and 16⅔ ounces of permanganate. The needle-shaped crystals of potassium permanganate should be employed. Place the required amount of permanganate in a wide-bottomed vessel (an ordinary dish pan is excellent) and pour the formalin on quickly, then close the compartment for from six to twelve hours, depending upon the character of the materials to be disinfected.

PRODUCTION OF THE GAS FROM PARAFORM AND FROM WOOD ALCOHOL.

Heating paraform.—Lamps provided with a pan for holding the paraform are obtainable on the market. The paraform is placed in the pan and heat applied by means of an alcohol lamp. The evolution of gas in this manner is slow. Two ounces of paraform is required for the disinfection of 1,000 cubic feet of space, and the compartment should remain closed for at least twelve hours. This method is best suited to the disinfection of small spaces.

Generation of formaldehyde from wood alcohol.—Formaldehyde is readily produced by the oxidation of wood alcohol (methyl alcohol). This fact has been taken advantage of for use in practical disinfection. Lamps have been designed by means of which the vapor of wood alcohol is passed over hot, finely divided platinum. This causes the oxidation of the alcohol to formaldehyde, which is given off in the room to be disinfected. There is somewhat more danger from fire when this method is employed than in those previously described. Not less than 25 ounces of wood alcohol should be employed for disinfecting 1,000 cubic feet of space.

ADVANTAGES AND DISADVANTAGES OF FORMALDEHYDE

The advantages may be summarized as follows:

(1) It is one of the most powerful germicides known.

(2) Its action is not interfered with by albuminous substances.

(3) It is not poisonous and may therefore be used for disinfecting hay and grain without destroying these for food purposes.

(4) It is not injurious to delicate fabrics, paint, or metals. (Formalin solutions will attack iron, but not other metals.)

The disadvantages are, briefly, as below:

(1) The gas has a strong tendency to condense in cold weather and is not reliable as a disinfectant when the air temperature is below 50° F.

(2) It is necessary to seal tightly all compartments which are to be disinfected with the gas in order that penetration may be secured and that the required concentration may be maintained for a sufficient length of time.

CARBOLIC ACID (PHENOL).

Pure carbolic acid is solid at ordinary temperatures and crystallizes in long white needles. It may be purchased in this form or as liquefied carbolic acid (Phenol liquefactum, U. S. P.). The latter form is prepared by adding 1 part of water to 9 parts of the crystals and is employed by pharmacists on account of convenience in dispensing. Carbolic acid must not be confused with "crude carbolic acid" and "liquid carbolic acid," which are described below.

For disinfecting purposes carbolic acid is generally used in watery solution, though powders containing it are sold. A 5 per cent solution of crystallized carbolic acid in water is recommended for general use, for, although weaker solutions have been found efficient for destroying many nonspore-bearing bacteria, the conditions found in practice vary widely and in some cases hinder the action of the disinfectant. As carbolic acid dissolves slowly, the 5 per cent solution should be prepared with warm water, using care to see that all is dissolved before use. For disinfecting large surfaces a spray may be used and the disinfectant should be applied liberally. Garments or implements to be disinfected should remain in the 5 per cent solution for at least one hour.

ADVANTAGES AND DISADVANTAGES OF CARBOLIC ACID.

The advantages are:

(1) It is reasonably effective for destroying nonspore-bearing bacteria.

(2) Its action is only slightly interfered with by albuminous substances.

(3) It does not destroy metals or fabrics in a 5 per cent solution.

(4) It is readily available at all pharmacies.

The following disadvantages may be mentioned:

(1) It can not be depended upon to destroy the spores of such acteria as anthrax and malignant edema.

(2) It is expensive (the pure phenol costs approximately 75 cents er pound).

CRUDE CARBOLIC ACID.

Probably no substance is so widely used in this country as a houseold and farm disinfectant as crude carbolic acid, and at the same me there is probably no disinfectant that is so uncertain in its effect used without a proper understanding of its nature. The comercial crude carbolic acid is one of the products of coal-tar distillaon, and consists essentially of a mixture of coal-tar oils and so-called resylic acid " with little or no phenol. The oils are practically inert disinfectants, but the cresylic acid, which is a mixture of cresols d similar homologues of carbolic acid, has very marked disinfecting wer.

As crude carbolic acid depends almost exclusively upon the cresylic d which it contains for its disinfecting power, it should not be ployed unless the cresylic acid content is definitely known. Even n it must be regarded as of doubtful efficiency if the percentage hydrocarbon oils is relatively very large, for the oil will prevent to great extent the solution of the cresylic acid in water when this is xed with the crude carbolic acid for use as a disinfectant. As is ted in the paragraph dealing with cresol, the cresylic acid is used 2 per cent solution in water as a disinfectant. When crude carlic acid is employed, the amount of "acid" which it contains ould be known and the disinfecting solution should be made of such rength that it will contain 2 per cent of cresylic acid. This disincting solution or mixture is best applied by means of a spray pump, d while spraying the mixture should be well agitated in order that e oils containing undissolved cresols may be evenly distributed over e surface to be disinfected.

There are found on the market products which are sold as "liquid rbolic acid," "straw-colored carbolic acid," etc.; these, as a rule, ntain from 90 to 98 per cent of cresylic acid and very little coal-tar il. They are considered in the next section dealing with cresols.

CRESOL.

Cresol (tricresol, straw-colored carbolic acid, liquid carbolic acid) derived from coal tar and is found in the trade in varying degrees purity. The cresol of the United States Pharmacopœia is a colorless liquid, having a strong odor resembling that of carbolic acid. It consists of a mixture of three closely related bodies, all of which are superior to carbolic acid as disinfectants. The other grades of cresols usually contain a small percentage of impurities, and are sold as "liquid carbolic acid, 95 per cent," "straw-colored carbolic acid," etc. These usually contain from 90 to 98 per cent of cresol, and may be purchased under a guaranty to contain certain definite amounts of cresylic acid. Grades containing less than 90 per cent of cresylic acid are not so desirable as those of a higher degree of purity, as the coal-tar oils which are usually found in such products interfere with the solution of the cresols in water, as already stated.

The commercial cresols guaranteed to contain more than 90 per cent of cresylic acid are relatively cheap and well suited to the disinfection of cars, barns, and yards. For general disinfection a 1½ to 2 per cent solution of cresol in water should be used, allowance being made for the impurities when the cheaper grades are employed. Cresol is not easily soluble in water; therefore, in preparing solutions warm water should be used and care taken to see that all is dissolved before applying the solution. A 2 per cent solution of cresol is regarded as being a more efficient disinfectant than a 5 per cent solution of carbolic acid and should be applied in the same way.

ADVANTAGES AND DISADVANTAGES OF CRESOL.

Briefly, the advantages are:

(1) A 2 per cent solution of cresol is as efficient as a 5 per cent solution of carbolic acid.

(2) It is not interfered with by albuminous substances.

(3) It is cheaper than carbolic acid.

(4) It does not destroy metals or fabrics in a 2 per cent solution.

(5) It is more effective than carbolic acid for destroying spores of bacteria, such as anthrax.

The main drawback to the use of cresol is that it is not readily soluble in water, hence may be used in too weak solution unless great care is taken in the preparation of the solution.

COMPOUND SOLUTION OF CRESOL.

This preparation, known as liquor cresolis compositus, United States Pharmacopœia, is recognized as official by the last edition of the United States Pharmacopœia, and is a mixture of equal parts of cresol (U. S. P.) with a linseed-oil-potash soap. The mixture is a thick, dark, amber-colored fluid which mixes readily with water in all proportions to form a clear soapy solution. A very efficient disinfectant may be made from the commercial cresols or liquid car-ic acids of known strength by mixing these with the soap de- ibed in the United States Pharmacopœia under the heading iquor cresolis compositus." When other than United States Phar- copœia cresol is used a sufficient excess must be added to insure 50 cent of actual cresylic acid in the mixture. Compound solution cresol is recommended for use as a general disinfectant in a 3 to er cent solution in water. In this strength it will accomplish the ne results as a 1½ to 2 per cent solution of cresol and may be applied the same manner as a 5 per cent solution of carbolic acid.

t may be said in favor of the compound solution of cresol that it ssesses all the advantages of cresol, and in addition is far more dily soluble. It is, however, somewhat more expensive than cresol, ing to a stronger solution being required; this is in great measure npensated for by its ready solubility.

CHLORINATED LIME (CHLORID OF LIME).

his substance is prepared by exposing slaked lime to the action chlorin gas. It is a white powder which gives off a disagreeable r of chlorin, and decomposes rapidly upon exposure to air. It can be depended upon unless kept in hermetically sealed containers. is prepared for use in the general disinfection of cars, pens, or use by mixing 6 ounces with a gallon of water. This is applied erally, and infectious excreta must be mixed thoroughly with the ution to insure disinfection. Chlorinated lime is a powerful de- rant and is valuable for use in foul-smelling cesspools and similar ces.

s a disinfectant, chlorinated lime possesses no advantages over maldehyde, carbolic acid, cresol, etc. It has, moreover, certain advantages, chief among which are uncertainty of strength and tructiveness to metals and fabrics.

BICHLORID OF MERCURY.

his is a white crystalline substance which is also known as mer- ic chlorid and corrosive sublimate. It is usually prepared for use he form of tablets with ammonium chlorid, which facilitates the tion of the bichlorid in water. The bichlorid is used in solution water in a strength of 1 to 1,000, though solutions 1 to 500 may be loyed with correspondingly quicker action on nonspore-bearing teria and much more effective action on the spores of bacteria. hlorid of mercury is a violent poison, and has the property of bining with albuminoids to form inert compounds. These facts ssarily limit its usefulness as a general disinfectant. It should never be used to disinfect excreta, or substances containing blood or serous fluids. Bichlorid solutions should not be kept in lead or tin vessels, or poured through lead pipes, as the mercury combines with these metals and injures them, besides affecting the germicidal efficiency of the solution itself.

The chief advantage in the use of bichlorid of mercury lies in its great germicidal power when employed under proper conditions. The disadvantages are its poisonous nature, its tendency to attack certain metals, and the interference by albuminoids and other organic substances.

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1 U. S. DEPARTMENT OF AGRICULTURE.

2 **FARMERS' BULLETIN No. 346.**

THE COMPUTATION OF RATIONS FOR FARM ANIMALS BY THE USE OF ENERGY VALUES.

BY

HENRY PRENTISS ARMSBY, PH. D., LL. D.,
Director of the Institute of Animal Nutrition of The Pennsylvania State College; Expert in Animal Nutrition, Bureau of Animal Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., November 18, 1908.

Sir: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, the manuscript of an article on "The Computation of Rations for Farm Animals by the Use of Energy Values," by Dr. Henry Prentiss Armsby. This paper, aside from dealing with the subject in a general way, makes available to the farmer and feeder some of the results of the investigations carried on under Doctor Armsby's direction at the Institute of Animal Nutrition of The Pennsylvania State College in cooperation with this Bureau.

Very respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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IE COMPUTATION OF RATIONS FOR FARM ANIMALS BY THE USE OF ENERGY VALUES.

GENERAL PRINCIPLES.

COMPONENTS OF THE ANIMAL BODY.

The Machinery of the Body.

he essential working parts of the body contain a great variety of tances, but these may, for our present purpose, be grouped under e heads—water, ash, and protein. The bones, constituting the ework of the body; the ligaments, muscles and tendons which l together and move the bones; the skin and hair, or wool, which r and protect the body; the internal organs of circulation, respira-, digestion, excretion, and reproduction; the brain and nerves—in t, the whole mechanism of the body—can be regarded as being posed substantially of these three classes of substances.

ater.—Rarely less than half and sometimes as much as three-ths of the weight of the live animal consists of water. The pro-ion of water is greatest in young and lean animals and decreases ey become more mature or fatter.

sh.—The ash or mineral matter is the portion left after complete ing. Its presence is most familiar in the bones, but it is found ll parts of the body and is just as essential as water or protein. mounts to from 2 to 5 per cent of the weight of the body.

rotein.—Protein is the name given to a highly important group of stances, of which the white of egg, washed lean meat, the casein nilk, the gluten of wheat flour, etc., are familiar examples. They composed of the chemical elements carbon, hydrogen, oxygen, rogen, and sulphur. They are what are commonly called ganic" substances, which simply means that they may be burned pletely in air or oxygen. They differ from the other groups substances found in the animal body in containing sulphur and ecially nitrogen, the latter element constituting from 15 to 18 or per cent of their weight.

rotein is the basis of the living tissues of the body—the so-called toplasm—and is the substance through which life especially man-ts itself. In the body it is always associated with water and ash.

The Reserve Material of the Body.

Fat.—Besides its working parts, the body contains a store of reserve material in the form of fat. While the fat deposits in the body are of use mechanically as cushions between the various organs and as a protecting layer under the skin, nevertheless fat represents essentially a storage of material derived from food consumed in excess of the body's immediate needs. When the food is insufficient or entirely lacking, this store of surplus material is drawn upon, and the animal gradually becomes lean. The percentage of fat in the bodies of agricultural animals may vary greatly, but seldom falls below 6 or rises above 30 per cent.

Glycogen.—Besides fat there are stored up in the muscles, liver, and other organs of a healthy animal rather small amounts of a substance called "glycogen," belonging to the group of carbohydrates described in the next section. Neither fat nor glycogen contains the elements nitrogen or sulphur, but each is composed entirely of carbon, hydrogen, and oxygen.

Composition of the Entire Body.

The average results of analyses shown in the following table indicate the composition of the bodies of different animals in different conditions:

Percentage composition of live animals.

	Ox.			Fat calf.	Sheep.					Swine.	
	Well fed.	Half fat.	Fat.		Lean.	Well fed.	Half fat.	Fat.	Very fat.	Well fed.	Fat.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Water	54.3	50.2	43.6	60.1	56.6	53.7	50.7	44.8	39.0	53.9	[illegible]
Ash	4.8	4.4	3.9	4.5	3.4	3.3	3.2	2.9	2.8	2.7	[illegible]
Fat	7.1	14.9	26.8	13.1	8.6	13.2	18.3	28.1	37.2	22.5	[illegible]
Protein	15.8	15.5	13.7	15.3	15.4	14.8	13.8	12.2	11.0	13.9	[illegible]
Contents of stomach and intestines	18.0	15.0	12.0	7.0	16.0	15.0	14.0	12.0	10.0	7.0	[illegible]
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	[illegible]

COMPONENTS OF FEEDING STUFFS.

Like the animal body, the vegetable feeding stuffs which nourish it contain a great variety of substances, but these, too, like those of the animal, may be classified into a few groups. Not only so, but these main groups are the same as those found in the animal, viz, water, ash, protein, fats, and carbohydrates. The proportions of these ingredients in the animal body and in vegetable substances, however, are widely different.

Protein and Fat.

Protein is the predominant ingredient, aside from water, in the animal body, while the latter stores up its reserve material in the form of fat with but little carbohydrates (glycogen). Protein is also contained in all plants and, as in the animal, forms the basis of the living tissues, but the predominant ingredients as regards quantity are the carbohydrates. In the form of cellulose, or " crude fiber," they form the cell-walls of the plant, while as starch and sugar they are stored up in large amounts in the cells of seeds and roots as reserve material. A few plants, like flax and cotton, store up oil instead of starch and are likewise rich in protein, but as a rule the common feeding stuffs contain relatively small amounts of protein and fat and are rich in carbohydrates.

The protein and fats of plants are not widely different from those of animals and call for no special description here.

Carbohydrates.

The carbohydrates, as starch, sugar, etc., constitute a distinct group, represented in the animal chiefly by the small amounts of glycogen mentioned on page 6 and by the sugar of the milk. They are composed of the chemical elements carbon, hydrogen, and oxygen, the two latter being present in exactly the same relative amounts as in water. Like the fats, they contain no nitrogen or sulphur, but they differ from the fats in containing less carbon and more oxygen.

The carbohydrates of feeding stuffs may be divided into two classes. The first of these includes those substances which are found in the cell walls and constitute the framework of the plant. This class includes cellulose and a great variety of other substances, most of which are rather difficult to dissolve. The " crude fiber " obtained in the analysis of feeding stuffs represents this class of carbohydrates.

The second class of carbohydrates consists of the reserve material stored up in the cells and includes starch, the various kinds of sugar, and other less familiar substances. Some of these carbohydrates, like the sugars, dissolve in water and all may be converted into soluble forms rather easily. In analyses of feeding stuffs they are contained in the " nitrogen-free extract " which, however, also includes a variety of other substances of ill-defined nature.

Average Composition of Feeding Stuffs.

The following table shows the average composition of a considerable number of American feeding stuffs. In this table the common practice has been followed of dividing the group of carbohydrates into two portions. The " crude fiber " or " woody fiber " is stated separately, partly because it is of somewhat inferior nutritive v and partly because it gives some indication of the bulkiness woodiness of the feeding stuff. The column headed "nitrogen- extract" includes all the carbohydrates except the crude fiber—tha the sugar, starch, etc.

Average composition of feeding stuffs.

[From Farmers' Bulletin No. 22, revised edition.]

Feeding stuff.	Water.	Ash.	Crude protein.[a]	Carbohydrates.	
				Crude fiber.	Nitrogen-free extract.
Green fodder and silage:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Alfalfa	71.8	2.7	4.8	7.4	12.3
Clover—crimson	80.9	1.7	3.1	5.2	8.4
Clover—red	70.8	2.1	4.4	8.1	13.5
Corn fodder	79.3	1.2	1.8	5.0	12.2
Corn silage	74.4	1.5	2.2	5.8	15.0
Hungarian grass	71.1	1.7	3.1	9.2	14.2
Rape	85.7	2.0	2.4	2.2	7.1
Rye fodder	76.6	1.8	2.6	11.6	6.8
Timothy	61.6	2.1	3.1	11.8	20.2
Hay and dry coarse fodders:					
Alfalfa hay	8.4	7.4	14.3	25.0	42.7
Clover hay—red	15.3	6.2	12.3	24.8	38.1
Corn forage, field cured	42.2	2.7	4.5	14.3	34.7
Corn stover, field cured	40.5	3.4	3.8	19.7	31.5
Cowpea hay	10.7	7.5	16.6	20.1	42.2
Hungarian hay	7.7	6.0	7.5	27.7	49.0
Oat hay	16.0	6.1	7.4	27.2	40.6
Soy bean hay	11.3	7.2	15.4	22.3	38.6
Timothy hay	13.2	4.4	5.9	29.0	45.0
Straws:					
Oat straw	9.2	5.1	4.0	37.0	42.4
Rye straw	7.1	3.2	3.0	38.9	46.6
Wheat straw	9.6	4.2	3.4	38.1	43.4
Roots and tubers:					
Carrots	88.6	1.0	1.1	1.3	7.6
Mangel-wurzels	91.2	1.0	1.4	.8	5.4
Potatoes	78.9	1.0	2.1	.6	17.3
Rutabagas	88.6	1.2	1.2	1.3	7.5
Turnips	90.6	.8	1.3	1.2	5.9
Grains:					
Barley	10.9	2.4	12.4	2.7	69.8
Corn	10.9	1.5	10.5	2.1	69.6
Corn-and-cob meal	15.1	1.5	8.5	6.6	64.8
Oats	11.0	3.0	11.8	9.5	59.7
Pea meal	10.5	2.6	20.2	14.4	51.1
Rye	11.6	1.9	10.6	1.7	72.5
Wheat	10.5	1.8	11.9	1.8	71.9
By-products:					
Brewers' grains—dried	8.0	3.4	24.1	13.0	44.8
Brewers' grains—wet	75.7	1.0	5.4	3.8	12.5
Buckwheat middlings	11.8	4.8	28.0	6.3	41.9
Cotton-seed meal	8.2	7.2	42.3	5.6	23.6
Distillers' grains—dried—					
Principally corn	7.0	2.0	29.2	11.0	39.4
Principally rye	6.8	2.1	17.3	12.3	54.0
Gluten feed—dry	8.1	1.3	23.2	6.4	54.7
Gluten meal—Buffalo	8.2	.9	24.5	6.1	47.8
Gluten meal—Chicago	8.1	1.0	28.3	1.1	50.8
Linseed meal—old process	9.2	5.7	32.9	8.9	35.4
Linseed meal—new process	9.9	5.6	35.9	8.8	36.8
Malt sprouts	10.2	5.7	23.2	10.7	48.5
Rye bran	11.8	3.5	14.7	3.5	63.9
Sugar-beet pulp—fresh	89.9	.4	1.0	2.2	6.3
Sugar-beet pulp—dried	6.4	3.3	10.8	19.8	58.4
Wheat bran	11.9	5.8	15.4	9.0	53.9
Wheat middlings	11.8	4.8	28.0	6.3	41.9

[a] Total N × 6.25.

THE ANIMAL BODY AS A MACHINE.

Mechanically the body of an animal is a very wonderful machine, ut what is of peculiar interest in this connection is that the body is what the engineer calls a prime motor—that is, like the steam or gasoine engine, it moves itself and may supply power to move other machines. In fact, there is in some respects a very close likeness between the animal body and what are known as internal-combustion motors, i. e., those engines in which power is developed by burning liquid or gaseous fuel (gasoline, alcohol, producer gas, etc.) in the ylinder of the engine itself. Such an engine requires two things for ts operation: (1) Sufficient repair material to keep its working parts n running order, and (2) a supply of fuel in proportion to the work o be done. Just these same two things are what the animal equires—repair material and fuel.

In one respect, however, the animal body differs from the artificial machine—it can not be stopped and started again at will. As long as he animal lives the vital machinery is in operation, although less ctively at some times than at others. The animal might be compared to an automobile whose engine must be kept running at a low peed in order to have the power available when needed. Consequently, the animal requires to be supplied with repair material and with fuel as long as it lives and not merely when it is in active use.

That the feed of the animal is its source of both repair material and uel is sufficiently obvious. We do not need a physiologist to tell us hat when an animal is deprived of food its tissues waste away while ts fat is burned up in the effort to keep the bodily machinery in moion. We may proceed at once, therefore, to consider the feed in hese two relations.

The Demand for Repair Material.

The repair material for any machine must be of the same kind of which the machine is made. We have just seen that the machinery of he body is composed of protein, ash, and water. These, then, are he materials which must be supplied to keep it in repair.

Water, of course, is or should be abundantly supplied in the drink nd scarcely need be considered in a discussion of rations.

Ash.—The ash supply has received less attention in the past than s importance deserves. In the ordinary operation of the bodily mahinery its ash ingredients are being continually excreted and the food must supply ash sufficient in amount and of the right kinds to make good the loss, while the growing animal needs an additional upply for building up its new tissues. Fortunately, normally contituted rations appear to be rarely deficient in ash. Usually it is only when large amounts of certain by-product feeds are used or when there is a misrelation between grain and coarse fodder that special attention needs to be given to the ash supply.

Protein.—The protein supply, on the other hand, calls for careful consideration. Protein is the characteristic ingredient of the animal mechanism, and is broken down and destroyed in its operation at a fairly regular rate. Moreover, since the bodily machinery is running all the time, whether any external work is done or not, this loss is continually going on.

The body differs from a machine in being self-repairing, but it can not manufacture protein for repair purposes out of the carbohydrates and fats of its feed any more than it is possible to make repairs for an automobile out of the gasoline which supplies the power. For its protein the body is absolutely dependent on the protein of the feed. This protein is needed for two purposes.

First. It is required for repair purposes in the strict sense; i. e., for making good the wear and tear of the bodily machinery. The amount needed for this purpose is comparatively small, and is no greater under normal conditions when the animal is doing work than when it is not. Like a good engine, the body makes relatively small demands for repair material and requires chiefly fuel.

Second. Protein as well as ash is needed in the growing, pregnant, or milking animal to furnish the material for enlarging the working machinery of the body of the animal itself or of its young. The amount of protein required for this purpose is just so much in addition to that needed for repair purposes simply, and hence the feed of these animals must contain a more liberal supply of this ingredient. This is important physiologically to secure proper nutrition of the young and economically because the growth or milk produced is the principal object of the feeder.

Feed as a Source of Repair Material.

For the reasons stated on page 9, the ash has generally been omitted from consideration in discussing the feed as a source of repair material.

The value of a feeding stuff as a source of protein to the animal body evidently depends in the first place on the amount of protein which it contains. Cotton-seed meal, carrying some 43 per cent of protein, is evidently, other things being equal, a better source of protein than Indian corn, carrying about 10 per cent.

In the second place, however, the protein of the feeding stuff must be capable of being digested by the animal. Of two feeding stuffs containing equal amounts of protein, that one is the more valuable as a source of supply in which the larger proportion of the protein is digestible. The second column of the table on page 15 shows the average percentage of digestible protein contained in a number of the more common feeding stuffs. These figures are the average results of a considerable number of analyses of the feeding stuffs and a smaller number of determinations of their digestibility. Individual samples may vary more or less, and sometimes considerably, from the average.

A third question is at once suggested, viz, whether the digestible protein from different feeding stuffs is equally valuable to the animal. It is unlikely that this is *exactly* the case, but whether these probable differences are of much practical significance, especially in rations containing a number of feeding stuffs, seems doubtful. At any rate, the only course open at present is to assume them to be of substantially equal value.

The Demand for Fuel Material.

Since the animal machinery is running continually, it requires a continual supply of fuel material, the amount which is necessary depending upon the amount of work done. This fuel material consists chiefly of the carbohydrates and fats of the food, although if more protein be fed than is required for repair and construction purposes it, too, may be used as fuel, while the worn-out portions of the protein tissues are also utilized—that is, the bodily engine can burn up its own waste products as fuel. The unnecessary use of protein as fuel material, however, is wasteful, because protein is ordinarily more expensive to buy or to produce on the farm than are carbohydrates and fats.

If the fuel materials supplied in the food are just adequate to the work to be done, they are virtually burned up as a source of power. If more are supplied than are immediately needed, the body is able to store away the surplus for future use, much as we may fill up the gasoline tank of an engine. To a small extent the body stores up carbohydrates (in the form of glycogen), but most of its surplus fuel it converts into fat. The fat of the body, therefore, is its reserve of fuel. In fattening, the body is accumulating a surplus against future needs which man diverts to his own use as food. If the feed becomes insufficient, this store is drawn upon and the animal gradually becomes lean. Similarly, in growth and in milk production, the animal sets aside a part of the supply of both repair and fuel material in its food for its own growth or for the use of its young, and man appropriates the resulting meat or milk as repair and fuel material for his own body.

Feed as a Source of Fuel Material.

We can run an engine with various kinds of fuel. For the steam engine we may use coal or wood or petroleum; for the internal-combustion motor, gas, alcohol, or gasoline may be employed. Similarly, we supply the animal body with a great variety of feeding stuffs from which it has to extract its supply of fuel, and even the materials which it actually burns up are of various sorts.

These fuel materials are not all of equal value. A pound of good anthracite coal, for example, is, other things being equal, about 14 per cent more valuable as fuel than the same weight of alcohol, while a pound of fat in the food has over twice the fuel value of a pound of starch. Evidently, it will greatly simplify comparisons of different feeding stuffs and rations as sources of fuel material to have some simple method by which we can learn not only the amount of fuel material which the feed contains, but also the quality of that fuel. Such a basis of comparison is afforded by a study of the energy values.

Measurement of Energy.

Anything which has the capacity to do work is said to possess energy. Hence we say that the fuel of the engine and the feed of the animal possess energy, since they enable the engine or the body to do work. They hold this energy stored up in the " latent " or " potential " form of chemical energy. When they are burned in the engine or the body, this chemical energy is set free, part of it being converted into work and the rest escaping as heat.

Plainly, then, the value of a fuel, or of a feeding stuff so far as it serves as fuel, depends, in the first place, on how much chemical energy it contains. This can be measured without difficulty by converting it all into heat, by burning the substance, and measuring the heat produced. Various units have been employed in measuring heat, but the one used in this bulletin is the therm.

A therm[a] is the quantity of heat required to raise the temperature of 1,000 kilograms (2,204.6 pounds) of water 1° C. A pound of good anthracite coal would produce heat enough to raise the temperature of about 3,583 kilograms of water 1° C. Consequently, the chemical energy contained in the coal is 3.583 therms per pound. In precisely the same way the amount of chemical energy contained in many feeding stuffs has been measured. The following are the results of a few such determinations:

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[a] In the nutrition investigations and studies of foods and feeding stuffs made by this Department and by the State agricultural experiment stations, the results, so far as energy or fuel value is concerned, have been expressed in calories. There is consequently a large mass of available data so expressed. The calorie is the amount of heat required to raise 1 kilogram of water 1° C. (approximately 1 pound of water 4° F.). The small size of the unit has made it necessary to use inconveniently large numbers to express the fuel values of foods and feeding stuffs, a difficulty which is obviated by the use of the therm. As the latter unit is equivalent to 1,000 calories, available data, such, for example, as those in Farmers' Bulletin No. 22, can be readily given expression in the new unit. The use of the word therm, with the abbreviation *t.*, has also been proposed as the equivalent of the small (or gram) calorie, but it has not come into general use.

Chemical energy in 100 pounds.[a]

	Therms.
Timothy hay	175.1
Clover hay	173.2
Oat straw	171.0
Wheat straw	171.4
Corn meal	170.9
Oats	180.6
Wheat bran	175.5
Linseed meal	196.7

Utilization of Energy.

But the value of a fuel depends also upon how much of the chemical energy which it contains can be used. Hard coal contains plenty of energy, but it would not be of much use to run a gasoline engine. Wheat straw contains fully as much chemical energy as corn meal, but much of that energy can not be utilized by the animal machine.

Two causes combine to affect the utilization of the chemical energy contained in feeding stuffs.

First, more or less of the feed escapes from the body unburned. If a coal is of such quality that portions of it drop through the grate unconsumed, and if smoke and combustible gases are carried off through the stack, it is evident that a ton of it will supply far less heat to the boiler than it would if the combustion were perfect. The case of the feeding stuff is similar. Much of even the best feeding stuffs escapes digestion and is excreted in the dung, carrying with it a corresponding quantity of the chemical energy of the feed. More or less incompletely burned material is also contained in the urine, while ruminants, and to a certain extent horses, also give off combustible gases, arising from fermentations in the digestive tract. Thus about 22 per cent of the chemical energy of corn meal and fully 55 per cent of that of average hay has been found to escape in these ways.

Second, as already pointed out, the animal body has to extract its real fuel material from its feed, separating it from the relatively large proportion of useless material which it excretes. To effect this separation requires work and consumes energy, and this energy, of course, is not available for other purposes. The case is somewhat as if the gasoline engine had to distill its own gasoline and separate it from impurities. Moreover, when the animal eats more feed than is required simply to furnish energy to run its machinery, and hence is able to produce meat or milk, the process of converting the food into suitable forms to store up in the body seems to require a further expenditure of energy.

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[a] With 15 per cent moisture.

It is not, then, the total chemical energy contained in a feeding stuff which measures its value as fuel material to the body, but what remains after deducting the losses in the unburned materials of the excreta and the energy expended in extracting the real fuel materials from the feed and transforming them into substances which the body can use or store up. For example, while 100 pounds of corn meal contain, as stated, about 170.9 therms of chemical energy, only about 88.8 therms remain, after all these deductions have been made, to represent the actual value of the corn meal as a source of energy to the organism.

Energy Values of Feeding Stuffs.

While it is a comparatively simple matter to ascertain the total amount of chemical energy contained in a feeding stuff, the determination of the proportion of this energy which the body can actually utilize requires the use of complicated and costly apparatus (respiration apparatus or respiration calorimeter) and the expenditure of much time and labor. While much has been accomplished along this line, vastly more still remains to be done before we can claim to have even a fairly complete knowledge of the energy values of feeding stuffs. At the same time, enough has already been accomplished, chiefly through the investigations of G. Kühn and of Kellner at the Möckern Experiment Station in Germany, since 1882, and in part also by experiments carried on, in cooperation with this Department, by the Institute of Animal Nutrition of The Pennsylvania State College, to demonstrate that the method still generally current of comparing feeding stuffs on the basis of the digestible matter which they contain is seriously erroneous and to furnish the beginnings of a reform.

The last column of the following table contains the energy values of the feeding stuffs, whose composition was given on page 8, computed on the basis of Kellner's investigations. They are what Kellner calls *production values*—i. e., they show primarily the value of these different feeding stuffs for the production of gain in mature fattening cattle. Even for this purpose many of them are confessedly approximate estimates, and still less can they be regarded as strictly accurate for other kinds of animals and other purposes of feeding. Nevertheless, there seems to be reason for believing that they also represent fairly well the relative values of feeding stuffs for sheep at least, and probably for horses, and for growth and milk production as well as for fattening. At any rate, there can be little doubt that they are decidedly more accurate than the figures which have been commonly used, and we are quite justified in using them tentatively and subject to correction by the results of later experiments.

As regards swine, the matter is far less certain, and it may perhaps be questioned whether the values given in the table are any more satisfactory for this animal than the older ones.

Dry matter, digestible protein, and energy values per 100 pounds.

Feeding stuff.	Total dry matter.	Digestible protein.	Energy value.
Green fodder and silage:	*Pounds.*	*Pounds.*	*Therms.*
Alfalfa	28.2	2.50	12.45
Clover—crimson	19.1	2.19	11.30
Clover—red	29.2	2.21	16.17
Corn fodder—green	20.7	.41	12.44
Corn silage	25.6	1.21	16.56
Hungarian grass	28.9	1.33	14.76
Rape	14.3	2.16	11.43
Rye	23.4	1.44	11.63
Timothy	38.4	1.04	19.08
Hay and dry coarse fodders:			
Alfalfa hay	91.6	6.93	34.41
Clover hay—red	84.7	5.41	34.74
Corn forage, field cured	57.8	2.13	30.53
Corn stover	59.5	1.80	26.53
Cowpea hay	89.3	8.57	42.76
Hungarian hay	92.3	3.00	44.03
Oat hay	84.0	2.59	36.97
Soy bean hay	88.7	7.68	38.65
Timothy hay	86.8	2.05	33.56
Straws:			
Oat straw	90.8	1.09	21.21
Rye straw	92.9	.63	20.87
Wheat straw	90.4	.37	16.56
Roots and tubers:			
Carrots	11.4	.37	7.82
Mangel-wurzels	9.1	.14	4.62
Potatoes	21.1	.45	18.05
Rutabagas	11.4	.88	8.00
Turnips	9.4	.22	5.74
Grains:			
Barley	89.1	8.37	80.75
Corn	89.1	6.79	88.84
Corn-and-cob meal	84.9	4.53	72.05
Oats	89.0	8.36	66.27
Pea meal	89.5	16.77	71.75
Rye	88.4	8.12	81.72
Wheat	89.5	8.90	82.63
By-products:			
Brewers' grains—dried	92.0	19.04	60.01
Brewers' grains—wet	24.3	3.81	14.82
Buckwheat middlings	88.2	22.34	75.92
Cotton-seed meal	91.8	35.15	84.20
Distillers' grains—dried—			
Principally corn	93.0	21.93	79.23
Principally rye	93.2	10.38	60.93
Gluten feed—dry	91.9	19.95	79.32
Gluten meal—Buffalo	91.8	21.56	88.80
Gluten meal—Chicago	90.5	33.09	78.49
Linseed meal—old process	90.8	27.54	78.92
Linseed meal—new process	90.1	29.26	74.67
Malt sprouts	89.8	12.36	46.33
Rye bran	88.2	11.35	56.65
Sugar-beet pulp—fresh	10.1	.63	7.77
Sugar-beet pulp—dried	93.6	6.80	60.10
Wheat bran	88.1	10.21	48.23
Wheat middlings	84.0	12.79	77.65

FEED REQUIREMENTS.

Assuming that the foregoing table represents with a fair degree of accuracy the amount of repair material (protein), on the one hand, and of energy, on the other, which the various feeding stuffs can supply, we still need to know how much of each is required by the bodies of animals of different kinds and kept for different purposes; in other words, we need some formulation of the feed requirements of farm animals.

Requirements for Maintenance.

Since the animal machine can not be stopped when it is not in active use, it requires, as was pointed out on page 9, and as is a familiar fact of experience, a continual supply of food. This amount of food, which is required simply to support the animal, is commonly designated as the "maintenance requirement"—i. e., it is the amount required simply to maintain the animal when it is doing no work and producing nothing. In other words, it is the least amount on which life can be permanently maintained.

The maintenance requirement is naturally greater for a large than for a small animal. Experiment has shown, however, that this increase is not proportional to the weight of the animal, but approximately to the amount of surface which it exposes, so that the large animal requires less food in proportion to its weight to maintain it than does the small one.

The following tables show the amounts of protein and of energy required per head for the maintenance of cattle, sheep, and horses of different weights. The figures given for sheep include a sufficient allowance for the normal growth of wool. No very satisfactory figures for swine are available. It should be understood that strict accuracy is not claimed for these figures, although they are substantially correct. In particular there seems to be reason to believe that the maintenance requirement of fattening animals increases somewhat more rapidly than these tables indicate.

Maintenance requirements of cattle and horses, per day and head.

Live weight.	Cattle.		Horses.	
	Digestible protein.	Energy value.	Digestible protein.	Energy value.
Pounds.	*Pounds.*	*Therms.*	*Pounds.*	*Therms.*
150	0.15	1.70	0.30	2.00
250	.20	2.40	.40	2.80
500	.30	3.80	.60	4.40
750	.40	4.95	.80	5.80
1,000	.50	6.00	1.00	7.00
1,250	.60	7.00	1.20	8.15
1,500	.65	7.90	1.30	9.20

Maintenance requirements of sheep, per day and head.

Live Weight.	Digestible protein.	Energy value.
Pounds.	*Pounds.*	*Therms.*
20	0.23	0.30
40	.05	.54
60	.07	.71
80	.09	.87
100	.10	1.00
120	.11	1.13
140	.13	1.25

Requirements for Growth.

ıile young animals gain in weight faster than do older ones, a l of increase in live weight in the young animal contains much water and less dry matter than in the case of a more mature ıl. Moreover, the dry matter in the case of the young animal ins relatively more protein and less fat, as a rule, than in the one, and fat contains much more chemical energy than protein, roportion being 1 to 1.67. The consequence is that a gain of 1 l in live weight represents the storing up of much less energy e young than in the mature animal, and therefore requires a er supply of energy in the food.

fortunately no very extensive determinations of the composition nergy values of the increase of live weight in growing animals yet been reported. The following estimates by the writer, ed from such data as are available, may serve to give a general of the requirements per pound of growth of cattle and sheep at ent ages, but they can not lay claim to any high degree of acy. The figures refer to normal growth, with no considerable ıing.

ıted energy value of 1 pound of gain in weight by growing cattle and sheep.

Age.	Energy value.
Months.	*Therms.*
3	1.50
6	1.75
12	2.00
18	2.50
24	2.75
30	3.00

e growing animal also requires a sufficient supply of digestible ın for maintenance and to supply material for new growth. ry systematic study of the latter requirement has yet been made, rom the results of a considerable number of practical feeding

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trials it is possible to make a fairly satisfactory estimate of th amounts of digestible protein which should be contained rations of cattle and sheep at different ages to insure satisf growth. These estimates are contained in the following table. are expressed in pounds per head and *include the maintenan quirement.* As a matter of convenience, the table also contai estimated energy values required per head for normal growth, thus constitutes a set of approximate feeding standards. In use the weight rather than the age of the animal should be th trolling factor.

Estimated requirements[a] *per day and head.*

FOR GROWING CATTLE.

Age.	Live weight.	Digestible protein.	Energy value.
Months.	*Pounds.*	*Pounds.*	*Therms.*
3	275	1.10	5.0
6	425	1.30	6.0
12	650	1.65	7.0
18	850	1.70	7.5
24	1,000	1.75	8.0
30	1,100	1.65	8.0

FOR GROWING SHEEP.

6	70	0.30	1.30
9	90	.25	1.40
12	110	.23	1.40
15	130	.23	1.50
18	145	.22	1.60

[a] Including the maintenance requirement.

No satisfactory data for colts are available, while, as noted on 15, our knowledge of the relative values of feeding stuffs for swi somewhat deficient.

Requirements for Fattening.

The foregoing data refer to what might be called normal growt which the animals are kept in a good thrifty condition, but do become fat. If any considerable fattening is desirable, some heavier rations must be given in proportion to the amount of made, because the increased gain in fattening animals consis a very large extent of fat, and therefore means the storing up b animal of more reserve energy. For fairly mature fattening mals—such, for example, as the 2 to 3-year-old steers which are monly fattened in the corn belt—probably 3.5 therms per pour gain in live weight is a fair allowance, although more appears often used in practice. As yet no corresponding data are avai for the fattening of growing animals, as, for example, in the duction of the so-called "baby beef." It is not probable, how t any larger amount of protein is required in such fattening than feeding simply for normal growth, so that the additional food en for fattening may, from this point of view, consist largely of nitrogenous material, i. e., carbohydrates and fats. It is to be ed, however, that an excess of these materials in the ration tends cause less perfect digestion, and also that a moderate proportion the more nitrogenous concentrates seems to aid in securing the sumption of heavy rations. Kellner recommends that at least 1 nd of digestible protein be supplied in the ration for each 8 to 10 nds of carbohydrates and fat.

Requirements for Milk Production.

Of all forms of animal production that of milk is perhaps the most riable and most influenced in its amount by the feed supply. The ergy relations of milk production have not been very fully investi- ted. Tentatively, however, it seems safe to estimate that the pro- ction of 1 pound of average milk, containing about 13 per cent of al solids and 4 per cent of fat, will require approximately 0.3 therm production value in the feed. Naturally this amount would vary th the quality of the milk, milk rich in fat and in total solids re- iring more than milk containing more water or a lower percentage fat.

The matter of the protein requirements for milk production has t been altogether cleared up. It seems to have been pretty well dem- strated that, for a time at least, milk production may be kept up a supply of protein very slightly exceeding that found in the milk oduced (of course, in addition to the maintenance requirement). the case of average milk, this would call for about 0.032 pound of gestible protein for each pound of milk. It has not been demon- ated, however, that a cow can keep this up indefinitely. Further- re, for the production of liberal yields of milk more protein seems be required, or at least to be advantageous. No definite statement n be made at present as to how large an excess is necessary. For ordinary commercial dairyman, however, it is believed that an owance of 0.05 pound of digestible protein per pound of milk will ove ample.

Requirements for Work.

Since the horse (or mule) is the usual working animal in the United tes, consideration will be limited to this animal.

There is on record a considerable amount of data as to the rela- n between the work performed by the horse and the amount of ergy necessary to be supplied in the feed. Where large numbers horses are kept and the work is relatively uniform in amount, it possible to make fairly satisfactory computations from these data, although the method is somewhat complicated. The amount of work required of farm horses, however, is so varied in amount and kind and so difficult of measurement or estimate as regards amount, that it is scarcely practicable to base the calculation of rations upon it. The table on page 15 probably shows with at least a fair degree of accuracy the relative values of different feeding stuffs as sources of energy for work production, while the amount to be fed will ordinarily be based upon the observation of the feeder rather than upon arithmetical calculations. As a sort of general average, however, Kellner recommends the following rations for a 1,000-pound horse, the amounts stated including the maintenance requirement:

Requirements of the working horse.

	Digestible protein.	Energy value.
	Pounds.	*Therms.*
For light work	1.0	9.80
For medium work	1.4	12.40
For heavy work	2.0	16.00

Dry Matter in Rations.

The total volume of feed which an animal requires, although rather variable, has its limits. In computing rations the most convenient indication of the bulk of the feeds is the percentage of dry matter shown in the first column of the table on page 15. In very general terms it may be said that a 1,000-pound ruminant should be given from 20 to 30 pounds of dry matter per day, 25 pounds being perhaps a fair average, while for the horse smaller amounts will be appropriate.

A study of the table shows that concentrated feeding stuffs contain much more protein and energy in proportion to their dry matter than do the forage crops. Evidently, then, in heavy feeding, where the purpose is to give the animal all the feed possible, the ration should consist as largely as practicable of concentrated feeding stuffs, because only in that way can the required amount of food be obtained without unduly increasing the bulk of the ration. On the other hand, in light feeding the coarse fodders may predominate, because they are usually relatively cheaper and can supply the required amount of food in a bulk which the animal can consume.

)VEMENT OF A RATION.

)le it was assumed that the feeding stuffs to upon and attention was directed simply to ,et us now take up the question from the · a study of the ration may not yield some ›rovement.

·n page 15, clover hay and corn-and-cob in 100 pounds—

	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
	84.7	5.41	34.74
	84.9	4.53	72.05

·y in the ration will evidently contain mounts given in the table, viz:

lry matter.
gestible protein.
nergy value.

·tion for the corn-and-cob meal gives

ry matter.
:estible protein.
·ergy.

l that the total ration contains:

	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
	6.78	0.43	2.78
	13.58	.72	11.53
	20.36	1.15	14.31

·, corresponds with that estimated ·s of feed were fixed upon on that he amount of digestible protein ın is estimated on page 18 to be ·on like the above might produce ·ıll advantage of the capacity of ·ould most likely fall below that ·n the protein could be expected ·ne way of accomplishing this ·ed more clover hay, since it is ·ould make the ration more ·tter indicates that a mod- ·e early stages of the digestible protein in the tables is true protein—that is, it does not include the so-called "amids" of the "crude protein." Consequently the percentages, as well as the amounts estimated in the rations on succeeding pages, are somewhat smaller than in the older tables.

TOTAL FEED REQUIRED.

A bunch of "feeders" 2 to 3 years old, averaging 1,000 pounds per head, are to be fattened on clover hay and corn-and-cob meal. Such cattle, if of good grade, should weigh 1,400 pounds each when ready for market and should not require over two hundred days to make the gain of 400 pounds. They should therefore make an average gain of 2 pounds per day.

On page 18 it was estimated that a gain of 1 pound live weight requires about 3.5 therms energy value in the feed; for a daily gain of 2 pounds, therefore, the energy requirement would be 7 therms. To this must be added the maintenance requirement, which will increase as the animals grow heavier. For the average weight of 1,200 pounds it is sufficiently accurate to use the maintenance requirement computed in the table on page 16 for 1,250 pounds, viz., 7 therms. This makes the total energy requirement per day 14 therms on the average of the whole feeding period.

If we assume that 2 pounds of grain will be fed for each pound of hay, it is easy to compute from the figures in the last column of the table on page 15 the amount of feed required to supply 14 therms of energy, as follows:

	Therms.
In 100 pounds of clover hay	34.75
In 200 pounds of corn-and-cob meal	144.10
In 300 pounds of feed	178.85
In 1 pound of feed	.596

To supply 14 therms requires 14÷0.596=23.49 pounds of total feed, consisting of 7.83 pounds of clover hay and 15.66 pounds of corn-and-cob meal, or, in round numbers, 8 pounds of hay and 16 pounds of meal.

This, of course, represents the average ration for the whole feeding period. At the beginning the feed will naturally be lighter and consist to a larger extent of hay, while the amount of feed, and especially the proportion of grain, will be gradually increased until toward the end of the feeding the animals are consuming all the grain they will take, with only enough hay to insure the necessary bulk and proper digestion. Naturally, too, the form in which the corn is given will usually be varied in the course of the feeding.

IMPROVEMENT OF A RATION.

In the foregoing example it was assumed that the feeding stuffs to used had been decided upon and attention was directed simply to e quantity required. Let us now take up the question from the her end and see whether a study of the ration may not yield some ggestion of possible improvement.

According to the table on page 15, clover hay and corn-and-cob eal, respectively, contain in 100 pounds—

Feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
ver hay	84.7	5.41	34.74
rn-and-cob meal	84.9	4.53	72.05

The 8 pounds of clover hay in the ration will evidently contain ght one-hundredths of the amounts given in the table, viz:

84.7 ×0.08=6.78 pounds of dry matter.
5.41×0.08=0.43 pound of digestible protein.
34.74×0.08=2.78 therms of energy value.

A precisely similar computation for the corn-and-cob meal gives e following results:

84.9 ×0.16=13.58 pounds of dry matter.
4.53×0.16= 0.72 pound of digestible protein.
72.05×0.16=11.53 therms of energy.

Adding these amounts, we find that the total ration contains:

Kind and amount of feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
ver hay, 8 pounds	6.78	0.43	2.78
n-and-cob meal, 16 pounds	13.58	.72	11.53
Total	20.36	1.15	14.31

The quantity of energy, of course, corresponds with that estimated be necessary, because the amounts of feed were fixed upon on that sis. We observe, however, that the amount of digestible protein the ration is considerably less than is estimated on page 18 to be ded by cattle of this age. A ration like the above might produce r gains, but it would fail to take full advantage of the capacity of h cattle, for growth and the gain would most likely fall below that ich was anticipated. An increase in the protein could be expected make the ration more efficient. One way of accomplishing this ich naturally suggests itself is to feed more clover hay, since it is her in protein than the meal. This would make the ration more lky, and the rather low total for dry matter indicates that a mod-te increase in this direction is practicable. In the early stages of fattening in particular, at a time when we may suppose that the call for protein is greater than at subsequent periods, a freer use of clover hay would usually be practicable, as well as desirable on the score of economy. Even if we suppose the proportion of hay and grain reversed, however, and the ration to consist for a time of 16 pounds of hay and 8 pounds of meal the digestible protein is after all only slightly increased.

	Pounds.
16 pounds of clover hay contain of digestible protein	[illegible]
8 pounds of corn-and-cob meal contain of digestible protein	[illegible]
Total digestible protein	[illegible]

To make any marked change in the ration in this respect, it is evident that we must introduce into it some feed much richer in protein than either of those composing it. On consulting the table it is evident that what we need is one of the by-product feeds like gluten feed or meal, the oil meals, etc., and also that only a small amount of one of these will be needed to effect a marked change in the ration. Thus, if we substitute 2 pounds of old-process linseed meal for 2 pounds of the corn-and-cob meal, the ration will foot up as follows:

Kind and amount of feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
Clover hay, 8 pounds	6.78	0.43	[illegible]
Corn and-cob-meal, 14 pounds	11.87	.63	[illegible]
Old-process linseed-meal, 2 pounds	1.82	.55	[illegible]
Total	20.47	1.61	[illegible]

Thus at a comparatively small additional expense we are able to improve the ration materially by adding the lacking protein, and there is little doubt that the improved ration would produce a more rapid gain and, under ordinary conditions, a more profitable one as well, either by increasing the total gain or shortening the feeding period.

COMPUTING A RATION FROM GIVEN FEEDING STUFFS.

There are available for a dairy herd field-cured corn forage (including the ears), clover hay, corn meal, wheat bran, and gluten feed. The table on page 15 shows that these feeding stuffs, if of good average quality, will furnish in 100 pounds:

Feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
Corn forage	57.8	2.13	[illegible]
Clover hay	84.7	5.41	[illegible]
Corn meal	80.1	6.79	[illegible]
Wheat bran	88.1	10.21	[illegible]
Gluten feed	91.9	19.95	[illegible]

he cows average 850 pounds per head and have produced in vious years an average of 20 pounds of milk per day. According he table on page 16, the maintenance requirement of such animals day and head would be approximately—

Digestible protein	pound	0.45
Energy	therms	5.60

or the production of 20 pounds of milk of average quality there ld be needed, according to the estimates on page 19:

Digestible protein (0.05×20)	pound	1
Energy (0.3×20)	therms	6

he total feed requirements per day and head are therefore:

	Digestible protein.	Energy value.
	Pounds.	*Therms.*
aintenance	0.45	5.60
lk production	1.00	6.00
	1.45	11.60

he problem, then, is to find a mixture of the available feeding fs which will yield these amounts of digestible protein and of rgy and which shall have a suitable bulk.

he first step in the construction of a ration is to fix upon the ounts of coarse fodders. It is usually desirable to use as large a portion of these as possible, since they are usually cheaper sources food than grain. On the other hand, the amount of them which animal can consume is limited. Much depends upon the individ- animals, and the proper amount can only be told by trial, but we uld probably aim to get from 12 to 14 pounds of dry matter in the m of coarse fodder. Corn forage being a cheap feeding stuff, we ll naturally use this freely, with probably some hay for variety. a little trial, we find that 14 pounds of corn forage and 6 pounds clover hay will give us 12 pounds of dry matter and the amounts digestible protein and of energy shown below:

Kind and amount of feed.	Total dry matter.	Digestible protein.	Energy. value.
	Pounds.	*Pounds.*	*Therms.*
forage, 12 pounds	6.91	0.26	3.66
r hay, 6 pounds	5.08	.32	2.08
Total	12.02	.58	5.74

o this we have to add sufficient grain to bring the ration up to the uirement. The proper amount we must ascertain by trial. We will take, at a venture, 5 pounds of corn meal and 2 pounds of wheat bran. Adding this to the ration we have:

Kind and amount of feed.	Total dry matter.	Digestible protein.	[illegible]
	Pounds.	*Pounds.*	[illegible]
Corn forage, 12 pounds	6.94	0.26	[illegible]
Clover hay, 6 pounds	5.08	.32	[illegible]
Corn meal, 5 pounds	4.46	.34	[illegible]
Wheat bran, 2 pounds	1.77	.20	[illegible]
Total	18.25	1.12	[illegible]

Comparing these totals with the requirement as computed, we find that the ration is slightly deficient in energy and considerably so in digestible protein, while the rather low figure for dry matter shows that more feed may be added to it if desirable. Of the feeding stuffs available, gluten feed is the one richest in protein, and we naturally use this to make up for the lack of this material. We still need 0.30 pound of digestible protein in the ration, and this will be almost exactly supplied by 1½ pounds of gluten feed. Making this addition, the ration stands thus:

Kind and amount of feed.	Total dry matter.	Digestible protein.	[illegible]
	Pounds.	*Pounds.*	[illegible]
Corn forage, 12 pounds	6.94	0.26	[illegible]
Clover hay, 6 pounds	5.08	.32	[illegible]
Corn meal, 5 pounds	4.46	.34	[illegible]
Wheat bran, 2 pounds	1.77	.20	[illegible]
Gluten feed, 1½ pounds	1.38	.30	[illegible]
Total	19.63	1.42	[illegible]

This ration contains almost exactly the desired amount of digestible protein, but it supplies a surplus of energy which would probably tend to fatten the cows rather than to cause any marked increase in the milk flow. We wish, therefore, to reduce the energy content while retaining the same amount of protein. We can do this by taking out some material, such as corn meal, which supplies chiefly energy, and substituting for it a smaller quantity of some substance like gluten feed, rich in protein. Thus, exchanging 1 pound of corn meal for one-half pound of gluten feed gives us a ration which agrees very closely with the computed requirements:

Kind and amount of feed.	Total dry matter.	Digestible protein.	[illegible]
	Pounds.	*Pounds.*	[illegible]
Corn forage, 12 pounds	6.94	0.26	[illegible]
Clover hay, 6 pounds	5.08	.32	[illegible]
Corn meal, 4 pounds	3.56	.27	[illegible]
Wheat bran, 2 pounds	1.77	.20	[illegible]
Gluten feed, 2 pounds	1.84	.40	[illegible]
Total	19.19	1.45	[illegible]

ıis ration corresponds with the average requirement of the whole
, since it is based on its average performance. It hardly need be
that it should be modified to suit the requirements and capacities
ıe individual cows, the heavy milkers getting more and the lighter
less.

y proceeding in this manner, with a little patience we can usually
a ration corresponding as closely as is necessary to the require-
t, provided the feeds available admit of it. With a little experi-
one very soon learns to guess pretty closely, and with some prac-
finds the computations very easy. An exact agreement with the
irement need not be sought for, since in practice the composition
ıe feeds will probably vary more or less from the average of the
s.

THE CHOICE OF FEEDING STUFFS.

hen, as in the last example, feeding stuffs must be purchased in
r to get the desired relation between the protein and the energy
ıe ration, it is evident that often a wide range of choice may be
ed. In such a case the question at once arises which of the vari-
eeds available is it most economical to purchase, it being evident,
urse, that this is not necessarily the one offered at the lowest price.
simple method of determining this point is possible, because,
e have seen, the food serves two entirely distinct purposes in the
. Sometimes the supply of protein is the specially important
t, and in other cases what is needed is a supply of energy without
al reference to whether its source be protein or nonnitrogenous
rial. Consequently, the relative values of two feeding stuffs may
under different circumstances. Some writers have based their
arisons of the values of by-product feeds solely upon their con-
of protein, for the reason that such feeds are often bought espe-
y to supply this ingredient, while the fats and especially the car-
drates are usually produced in abundance upon the farm. They
rd that purchased feeding stuff as the most economical which fur-
es a pound of digestible protein at the lowest cost, ignoring any
e in the other ingredients. It is obvious, however, that this is a
sided view. The other ingredients have a value, and this is espe-
y true in the case of a feeder who buys a considerable part of his
n supply and depends upon it as a source of energy as well as of
ein. The method of comparison illustrated in the following pages
sed primarily upon the cost per unit of energy because this is on
whole the most important function of the feed, but the method
account also of the amount of protein present.

Let us suppose the following feeding stuffs are available to a dairyman at the prices named:

Prices of feeds per ton.

Oats (40 cents per bushel)	$25
Corn meal	25
Wheat bran	21
Wheat middlings	24
Dried brewers' grains	23
Gluten feed	27
Cotton-seed meal	30
Old-process linseed meal	33

The supply of coarse feed on the farm is sufficient to furnish each animal per day 32 pounds of silage and 8 pounds of clover hay; the cows average 1,000 pounds each and may be expected to produce about 24 pounds of milk per day.

The first step is to compute, in precisely the same way as in the previous example, the estimated requirements of these cows per day as follows:

	Digestible protein.	Energy value.
	Pounds.	*Therms.*
For maintenance	0.50	6.0
For 24 pounds of milk:		
Protein 24×0.05	1.20	
Energy 24×0.30		7.2
Total requirement	1.70	13.2

The amounts of silage and clover hay available will furnish, according to the table on page 15, the following amounts of dry matter, digestible protein, and energy value:

Kind and amount of feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pound.*	*Therms.*
Corn silage, 32 pounds	8.19	0.39	[illegible]
Clover hay, 8 pounds	6.78	.43	[illegible]
Total	14.97	.82	[illegible]

The question now is what feeding stuffs is it most economical to buy (or to refrain from selling if in stock) to complete the ration. The first step in deciding this question is to compare the various feeds as sources of energy and see which one furnishes a unit of energy at the lowest price. This computation gives the following s:

Kind of feed.	Cost of 100 pounds.	Energy value of 100 pounds.	Cost of 1 therm energy value.
		Therms.	*Cents.*
	$1.25	66.27	1.89
al	1.25	88.84	1.13
ran	1.05	48.23	2.18
iddlings	1.20	77.65	1.55
ewer's grains	1.15	60.01	1.92
eed	1.35	79.32	1.70
eed meal	1.50	84.20	1.78
ess linseed meal	1.65	78.92	2.09

idently, if it were simply a question of supplying energy to the ıls, we should use corn meal, since that supplies a unit of energy much lower price than any of the other feeding stuffs. If it thought desirable to add variety to the ration, wheat middlings l obviously be our next choice.

is evident, however, without going through the labor of compu- ı, that while corn meal and wheat middlings may be used in the ı, neither will supply enough protein if used exclusively. Of vailable feeding stuffs which are rich in protein and which may fore serve to balance the deficiency of this ingredient, gluten is relatively the cheapest, and cotton-seed meal comes next. e the difference between the two is not great, we shall naturally ie cheaper one. It is not difficult to determine by a few trials pounds of corn meal and 2½ pounds of gluten feed, in addition e coarse fodder available, will give a ration corresponding very y to the requirements, as the following table shows:

Kind and amount of feed.	Total dry matter.	Digestible protein.	Energy value.
	Pounds.	*Pounds.*	*Therms.*
ge, 32 pounds	8.19	0.39	5.30
ay, 8 pounds	6.78	.43	2.78
al, 4 pounds	3.56	.31	3.55
eed, 2½ pounds	2.30	.50	1.73
tal	20.83	1.63	13.36

is ration shows as close an agreement with the computed require- as could be desired. The comparatively low figure for dry mat- ıdicates that more coarse fodder might have been used had it available, with the probable effect of cheapening the ration. As we have used the feeds relatively lowest in price and apparently a very economical ration.

Since, according to the assumed figures, corn meal is relat
cheap as compared with the other feeding stuffs, we shall natu
try to use as large a proportion of this in the ration as practic
In order to increase the corn meal, however, it will plainly be n
sary to use some other feed richer in protein than gluten feed.
ton-seed meal is nearly as cheap as a source of energy as gluten
while it contains almost twice as much protein. We therefore
the effect of increasing the corn meal to 4½ pounds and usin
pounds of cotton-seed meal in place of the 2½ pounds of gluten
with the following results:

Kind and amount of feed.	Total dry matter.	Digestible protein.
	Pounds.	*Pounds.*
Corn silage, 32 pounds	8.19	0.29
Clover hay, 8 pounds	6.78	[illegible]
Corn meal, 4½ pounds	4.01	[illegible]
Cotton-seed meal, 1½ pounds	1.38	.54
Total	20.36	1.67

This ration agrees with the computed requirements even b
than the previous one, while a simple comparison shows that
actually a trifle cheaper. The grain portion of the two rations
as follows:

Feed in ration.	First ration.
	Cents.
Corn meal	5.00
Gluten meal	3.37
Cotton-seed meal	....
Total	8.37

It thus appears that a ration made up with the somewhat
expensive cotton-seed meal was actually cheaper because it was
sible to use more of the cheap corn meal. The difference, to be
is small, yet for 30 cows fed for 200 days, it would amount to
Such a difference is only likely to be found, however, when, a
assumed in this instance, some feed low in protein but rich in e
can be had at a relatively cheap rate. In general, it may be sai
when there are no very marked differences in the cost of a the
energy value in the feeding stuffs constituting the bulk of the
one of the various high-protein feeds which supplies energy
lowest cost should ordinarily be used, although it is always w
check up this point, as in the example just given.

le in the foregoing examples an exact daily ration is computed, ld, of course, be utterly impracticable in most cases to weigh arately each day's ration for each animal. Individual weigh- f feeds at intervals would often yield valuable information ight be profitably undertaken, but for the ordinary routine ling simpler methods must be used.

n practicable, the grain feed may be advantageously mixed in e in the desired proportions in as large quantities as the capacity available and the proper preservation of the ls will permit. Where facilities are available, the whole of grain required for all the animals may be weighed out daily, for each feeding, without much additional labor. In distribu- e grain to the individual animals, regard of course should to their productive capacity and their individual peculiarities. tion, as computed, is for the average animal. The skill of der is shown in adapting it in quality and in amount to the ual. Doubtless individual weighings at intervals, as already ed, would be useful as a control on the accuracy of the tion.

weighing of coarse fodder is usually a more difficult problem ount of its bulk. When, however, silage or cut fodder is d in trucks, the matter is still comparatively simple. Long on the contrary, is not readily weighed. Nevertheless, even n occasional weighing, if practicable, as a control upon the g, is very desirable.

ll these and similar matters common sense is necessary. The ted ration expresses the best estimate that can be made of the average requirements, but it is at best more or less of an imation. It would be foolish, therefore, to seek extreme ss in realizing it or to go to more expense in the weighing portioning of the feed than the saving in the latter would t to. The scale upon which the feeding is conducted will play ortant part. Where scores or hundreds of animals are being exactness may be profitably sought which would be absurd case of two or three animals. Finally, it should be remem- hat these computed rations are guides and not recipes. They d the feeder in wisely using the resources at his command, y can not take the place of experience and good judgment.

BEARING ON FARM MANAGEMENT.

The data and the methods of computation on previous pages will aid the feeder in determining the amounts of each class of feeds needed for each class of his animals. The man of good business habits will find them useful in determining the quantities of each kind of feed to grow or purchase and in deciding upon the purchase of animals to feed and the feeds to keep or to purchase for feeding them. These facts and methods will aid the farmer, the feeder, or the user of work animals in deciding upon the chances of profit in proposed enterprises. Often by using these formal ways of checking up a proposed business project the way is made more clear to avoid loss and to secure the largest practicable profit. In case of the farmer who grows most of his feed stuffs, these facts and methods of calculation may often be used in connection with the planning of his scheme of crop rotation and in proportioning the acreages of the respective crops to each other and to the numbers of each class of animals. They will prove useful in reducing the farm-management plan to a scientific basis.

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HE REPAIR OF FARM EQUIPMENT.

BY

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chie
Washington, D. C., April 2

Sir: I have the honor to transmit herewith a manuscript entitled "' pair of Farm Equipment," by Mr. W. R. Beattie, Assistant Horticultur recommend that it be published as a Farmers' Bulletin.

The proper care of farm equipment is a matter of great importance, i to obtain the greatest efficiency of the machinery and implements, but lengthen their period of service and lessen the cost of maintenance.

Respectfully,
B. T. Gallowa
Chief of B

Hon. James Wilson,
Secretary of Agriculture.

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THE REPAIR OF FARM EQUIPMENT.

INTRODUCTION.

he successful management of a modern farm depends largely upon efficiency of the equipment with which the work is performed. equipment of the average farm can be divided into about three e or less distinct classes, as follows: First, and most important, the buildings, fences, implements, machinery, wagons, and all liances used in the more important farming operations; second, isils and machinery used in connection with the dairy, garden s, butchering outfit, and the numerous small things for general about the place; third, the tools, materials, and facilities for ping the first two classes of equipment in repair and in good rking order. It is with the last class that this paper has to deal, object being to assist the farmer in the selection of a suitable l outfit, to suggest a line of supplies that are most commonly uired for making repairs, and to give hints regarding the proper e and uses of tools.

n order to secure the greatest efficiency, all implements and hinery should be properly housed when not in actual service, so o be in good working condition when required for use. Altera- is and repairs on buildings and fences are required from time ime to accommodate them to changed conditions and to protect crops. Farm machinery and equipment generally are subject to r and breakage, and constant attention to repairs is necessary. extent to which the repair work should be done on the farm will end entirely upon local circumstances. If there is a well-equipped p near-by where the repair work can be done by a trained mechanic hout loss of time it may be best to carry the greater part of such rk to the shop; but if the shop is at a distance, is poorly equipped, as is often the case, the mechanic in charge is incapable of turning good work, it will then be a saving to perform the work at home. ides, there is a large amount of repair work that can not be carried shop and must be done on the farm if it is done at all.

he importance of making repairs promptly.—Breakdowns are most uent during the busy season, and much valuable time may be lost and supplies are at hand.

The economy of making repairs on the farm.—Th
far to undertake to do repair work on the farm w
ably upon the personality of the farmer himself a
handle tools and execute the work. The regula
should be the primary consideration, and any re
work that will cause the neglect of crops should
By the aid of a little training, together with
and supplies, the farmer can repair all ordin
farm equipment; and as a rule he can do this in
would be required to go to a distant shop. If
economy of time, repairs made in a regular sho
mechanic would generally be found more satisfact
at home, but the saving in both time and expens
outfit an important adjunct to the farm equipme

The time for making repairs.—Much of the loss
breakage may be avoided by carefully inspecting
parts of the farm equipment before the rush o
begins. The proper time for making such repai
pated is during the winter months and at time
farm work is not pressing. As the season adva
that will be required for the next farming operati
out, gone over, and given any attention required
for immediate use. If the farm machinery is n
through the winter or during other periods of d
the more important that it should be given a c
After inspecting an implement, tightening bolts,
parts and renewing broken pieces, any necessary

The educational value of the use of tools.—The use of tools is of great ue as an educational feature, especially when the work is carefully formed. The boys on the farm should be encouraged in the use tools, but should be held responsible both for the care of the tools l the character of the work performed with them. The tool out- of the farm is of special service on stormy days and will aid atly in keeping the boys employed and contented to remain at ne.

Before beginning any piece of work, a definite plan should be ked out in detail, and if it requires the assembling of several ts each piece should be sketched on paper or on a board, so that n finished a close fitting of parts will be assured. It may be well dd a word of caution regarding the improper use of tools, for stant tinkering will work more harm than good. If a bolt is tight, is sufficient, and an extra turn with the wrench may strip the ads and cause trouble. The taking apart of machinery should be ded, except in cases where it is absolutely necessary to do so. The er and mower and other machines of this class are securely put ther at the factory, and if the parts are removed it is difficult to re them to their proper adjustments.

is doubtful whether horseshoeing,[a] wheelwright work, and repair k which requires special machinery can be economically performed the farm, except where the farming operations are sufficiently ensive to justify the establishment of a shop and the employment a mechanic.

TOOLS ADAPTED TO REPAIR WORK ON THE FARM.

he selection of the tool outfit will depend upon the scope and racter of the work to be performed.

n most farms there is a deficiency of suitable repair tools and sup- es, and an increased investment along this line is strongly recom- ded. Some farmers, however, need to be cautioned against hasty, scriminate purchases. A small, well selected outfit, used to the advantage and well cared for, will prove more satisfactory than rge miscellaneous assortment improperly kept and used.

n this bulletin no attempt is made to determine the extent of the air outfit which the individual farmer should purchase or the ount and scope of the work he should undertake. The problem one for each farmer to solve, as he alone is familiar with all the ditions. The aim here is to furnish information which will be eful to farmers of all classes in selecting repair outfits, whether

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For information on horseshoeing, see Farmers' Bulletin No. 179, which will sent free upon request to the Secretary of Agriculture.

they be large or small, leaving each farmer to decide th
which he should purchase and use the tools and supplies li

In nearly all localities most of the tools may be purchase
local hardware dealer. In many places there are stores
“ farmers’ supply houses ” from which many of the mo
tools may be purchased. In addition to these, many of
facturers of tools offer combination outfits, and the la
order ” houses of the country are prepared to supply t
kinds, either singly or in combinations. A number of
appliances described herein are not ordinarily found in t
stores, and these can be made either by a local mechanic
farm.

Under most circumstances it will pay to secure tool
quality, although fine exterior finish is not essential. To
inferior quality are offered at low prices, but they invari
a disappointment to the purchaser. The name of the ma
is a sufficient guaranty of the quality of many tools, an
chaser is advised to secure only those that are sold unde
anty from either the manufacturer or the dealer. Whe
plating the purchase of a collection of tools, make a car
to see just what ones are needed, then purchase all at one ti
liberal discount can generally be secured.

For the convenience of intending purchasers in making
of tools, lists with descriptions of those most commonly re
the farm are here given; also suggestive combinations v
price from $2.50 to $25. In describing the tools, they h
divided into classes, including wood-working, iron-working,
neous: and general-purpose tools, and special conveniences f
work. In making up the lower priced combinations, pref
given to the tools required for the more simple operations an
a broad range of utility.

WOOD-WORKING TOOLS.

In the case of certain tools more than one shape or style i
by dealers. In a few cases a particular type of tool is better
to use on the farm than others, and these differences are me
in connection with the following list.

Ax.—An ax is perhaps one of the first tools required upon
The ax properly belongs to the regular farm equipment, but in
as an ax which is used for general purposes on the farm is n
condition for use in making repairs, it is recommended that
two axes be on hand, one to be kept in first-class condition
be used for repair and construction work alone. Axes are of
grades and range in price from 75 cents to $1.50. Axes also

:tween 2 and 5 pounds, 4¼ or 4½ pounds being a good size
al use. It always pays to secure a good ax, and a hand-
tory handle is to be preferred to the cheaper machine-made

ε.—The tool commonly known as a hand ax is similar to a
chet or, rather, is a compromise between a hatchet and a
The blade of the hand ax is ground on one side only, and
ially adapted for
ving the side of
l for "roughing
letrees, tongues,
ar parts of ma-

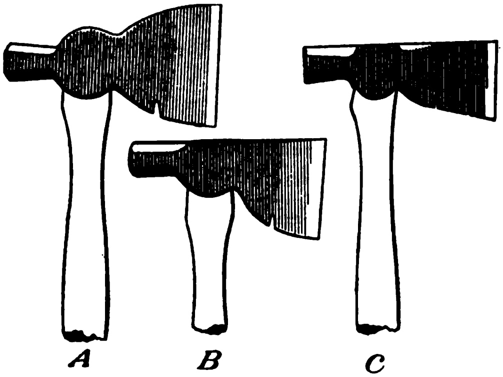
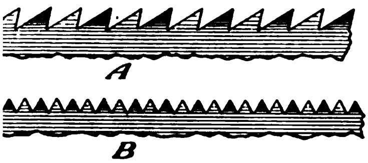


FIG. 1.—Three types of hatchet. The half hatchet (*B*) is best adapted for general farm use.

.—A hatchet is
ndispensable on
even where the
is very limited.
e several styles
es of hatchets
arket, the half-
fig. 1, *B*) being
he most service-

There is no tool where quality counts so much as in the
however, a good one can be secured for about 75 cents.

ws.—A good handsaw is almost as important on the farm
or a hatchet. A crosscut saw, having regular V-shaped
ost often required, but a ripping saw will be desirable where
nount of lengthwise sawing is to be done. The difference
pe of the teeth of the crosscut and ripping saws is shown
in figure 2. A crosscut saw
for general farm purposes
should not be too fine, one
having about 8 teeth to the
inch being desirable. If
more than one saw of this
class is kept, the collection
clude a No. 7 or No. 8 for the rougher work and a No. 11
cutting. A large-toothed crosscut saw can readily be used
f a ripping saw, especially if the teeth are filed a trifle on
of those of the ripping saw.



teeth : *A*, ripping saw ; *B*, crosscut saw.

oper sharpening of saws is essential, and unless one has
derable experience it will be desirable to have this work
l by a trained mechanic. The saw-sharpening outfit con-
ro thin boards between which the saw blade can be clamped

in the vise or workbench clamp, a "set" for use in giving th of the saw the proper spread, and a small three-cornered file. go over the teeth of the saw with the "set" and open the enough to give the blade clearance in the wood, being car spread the teeth in the same direction as they were originally. having properly opened the teeth proceed to sharpen them wi small three-cornered file. Hold the file with both hands, at a angle with the saw, and draw it about twice through each between the teeth. File one side of the saw at a time, skipping other notch; then reverse the blade and file the other side. It be the aim to retain the shape and pitch given the teeth factory.

Compass saw.—The compass, or bracket, saw is a narrow sa tapering to a point. The principal uses of a compass saw are f ting curved surfaces for the timber parts of implements, sawi cular openings, and sawing a slit from an auger hole in whi regular handsaw may be started.

Steel square.—For most purposes a square having a length inches on one arm and 16 or 18 inches on the other arm will be satisfactory. For lighter work a medium-sized square is conv and for very small and careful marking the try-square, mea about 4 by 6 inches, is desirable. The sta size square will be found most importan this can be secured at prices ranging fr cents to $1.50, or even higher. A smal square can be purchased for 25 or 30 cents.

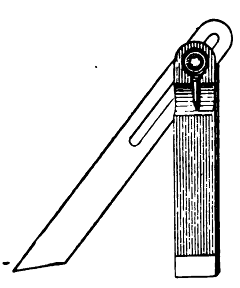


FIG. 3.—Bevel square.

Bevel square.—The bevel square (fig. 3) device one blade of which can be set a angle to the other. This tool is useful w number of pieces of material are to be c a given slope, the siding for the gable end building being a good example. The cost of a bevel square s be about 40 cents.

Drawing knife.—The uses of this implement on the farm a well known and numerous to require mention. The essential serviceable drawing knife are good steel in the blade and subst handles securely riveted. A first-class drawing knife adapt general purposes can be secured for about $1.

Brace and bits.—For boring holes not exceeding 1¼ inches in eter, a brace and a set of bits are essential. There are several of brace upon the market. The simpler forms can be secured for 50 cents each, while the more elaborate types with ball bearing ratchet shank frequently sell as high as $2.50. For ordinary the cheaper form of plain brace will answer, but for boring in quarters a ratchet brace that will work without turning the handle completely around is desirable.

The bits for use in the brace can be secured singly or in sets of 6, 8, or 12, including sizes ranging from one-fourth inch to 1¼ inches. A set containing eight bits will answer practically every requirement on the farm. The set containing twelve bits includes sixteenth-inch sizes and can be secured at prices from $2.50 upward. The brace and a full set of bits should not cost more than $5.

Gimlet bits.—For boring small holes in wood, especially for the insertion of wood screws, an assortment of gimlet bits is desirable. The uses of the gimlet bits are limited, however, and their place may be filled by the small sizes of twist drills which may be used for boring either wood or metals.

Screw-driver bit.—For setting wood screws in hard wood or for the removal of old ones there is nothing equal to a square-shank screw-driver that may be used in the brace. This little tool can be made from the shank of a broken carpenter's bit, from an old file, or a small piece of steel, or it can be purchased for 10 cents.

Screw-driver.—The common hand screw-driver is especially desirable for use about the dwelling and for light work on machinery. In order that a screw-driver should give good service it is essential that the metal part should consist of good steel and that it should extend through the handle and be securely riveted. The handle should also be protected from splitting by means of bands or rivets. This type of tool can be secured at prices ranging from 25 to 75 cents, according to size and quality.

Augers.—For boring holes larger than 1¼ inches in diameter it will be necessary to secure regular augers having T-style handles. By having the square shank of the augers of the same size and provided with a thread and nut at the end, one handle can be made to serve for all. There are handles on the market which are provided with an iron plate and thumbscrew for clamping to the auger shank.

If the cutting edges of an auger or a bit become dull, they may be sharpened with a small file. To merely sharpen an auger, file on the lower side of the cutting edges, being careful to keep them of the same pitch or bevel. In case a bit does not take sufficient hold, first see that the threads on the center point are clean; if the difficulty is not with the threads, then file the upper side of the cutting edges a little.

Jack plane.—The name "jack plane" is applied to that class of planes that are suited for general purposes, especially for rough work. The old form of wood-body jack plane with its wedge-set bit has been largely replaced by the more modern iron or combination wood and iron plane, with spring clamp and thread feed to regulate the bit. A very good 14-inch jack plane can be bought for $1.50.

Smoothing plane.—This tool is similar to the jack plane except that it is smaller and is designed for imparting a smooth finish after the rougher surface has been removed. The cost of a smoothing plane will be about $1.25.

In grinding the bit of a plane care must be taken to keep the edge square and to prevent the corners from becoming rounded. It is well to have a small square at hand and try the edge from time to time while grinding. After grinding the plane bit always finish on an oilstone, smoothing off any burr or rough edge that has been formed in grinding. Do not grind the plane bit every time it loses its keen edge, but simply whet it on the oilstone; grind it only when the oilstone fails to give a cutting edge. In resetting the bit in its place, first have the cutting edge of the bit a little higher than the lower surface of the plane, then after clamping it in place gradually feed it downward until the proper depth of cut is reached.

Wood chisels.—A number of chisels of sizes from one-half inch to 1½ inches are desirable. The type known as "socket and firmer," with a leather tip on the wood handle, is the best for general purposes. The price will vary with the size and quality from 25 cents to $1.50 each. A wooden mallet should be used for driving the chisels.

Claw hammer.—This common type of hammer is desirable for use around the house and outbuildings. The principle of construction gives great leverage for drawing nails. If a spike or long nail is to be drawn, the efficiency of the claw will be greatly increased by placing a rounded block of wood between the hammer and the plank from which the nail is being drawn. A medium-grade claw hammer can be secured for about 50 cents, but one of the highest quality will cost 90 cents to $1.

Claw bar.—Where a great many large nails are to be drawn or where old buildings are to be torn down, there is nothing superior to a claw bar (fig. 4). This tool can be made by any blacksmith from a piece of three-fourths or seven-eighths inch steel about 3½ feet in length. One end should be shaped somewhat like the claw of a hammer with a wedge-shaped slit for taking hold of nails. The opposite or handle end may be drawn to a chisel point, and serve as a bar for the prying apart of materials; or if drawn to a sharp point it is very useful for drawing staples. The length of handle and short fulcrum of this tool give a powerful leverage when applied to the pulling of spikes or bolts.

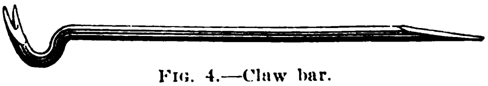


FIG. 4.—Claw bar.

Spokeshave.—The spokeshave (fig. 5), sometimes called a scraper, as been in general se for a long time nd is still one of he most useful tools, specially in the finshing of handles or nything that is shaved from wood. A good one can be purchased or 40 cents.

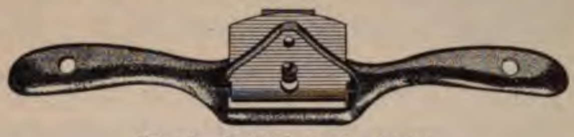
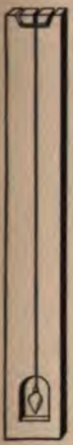


FIG. 5.—Spokeshave, or scraper.

Wood rasp.—The wood rasp is similar to a coarse file and is used for nishing any piece of wood which requires to be brought to a definite size. A wood rasp is desirable for use in fitting the handles of picks, mattocks, or hoes to their sockets. A 14-inch wood rasp will answer general purposes and should cost about 35 cents.

Folding rule.—Where some measuring device is frequently wanted, a folding rule that can be carried in the pocket will be found very convenient. Folding rules are made in lengths from 1 to 5 feet and can be secured as cheaply as 10 cents each, but one that will prove durable will cost 35 or 40 cents.



IG. 6.—Plumb rule made from a piece of board.

Chalk line.—Any hard-twisted string will serve as a chalk line. Cord made especially for this purpose can be secured for 10 or 15 cents a ball. Chalk for use on the line can be purchased for 5 cents a ball, or about 15 cents a pound. A halk line is especially desirable for securing a traight cut through a plank having irregular dges and in "laying off" a tapering tongue or imilar part of farm machinery.

Plumb rule.—A plumb rule is desirable for use n construction work and is also adapted to the etting of posts. A device of this kind (fig. 6) an be made from a piece of board, a bob, and a tring.

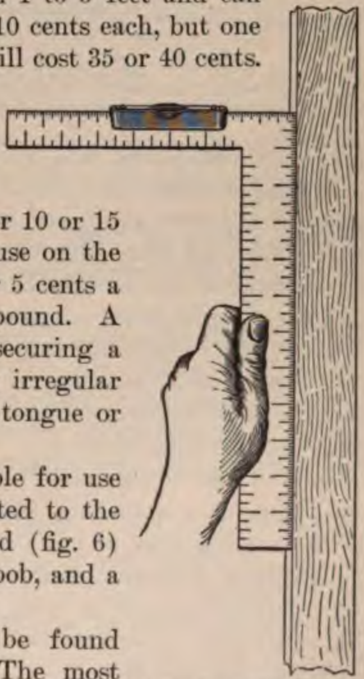


FIG. 7.—Spirit level used as a plumb.

Spirit level.—This implement will be found seful for a great many purposes. The most ommon form of spirit level consists of a bar of wood with a spirit tube mounted near the center. n the better grades a plumbing tube is inserted near one end. Levels f this kind cost from 40 cents to $1.50 each. There is a small, or pocket size, level (fig. 7) that is adapted for fastening on a steel square and may be used either for leveling or plumbing purposes. This form of level can be bought for 15 or 20 cents.

TOOLS AND EQUIPMENT FOR WORKING IRON.

The following list, together with short descriptions, includes the majority of the tools that will be required for handling metals in the repair of farm equipment. There are a few tools that are equally useful for working with both wood and metals; for instance, twist drills may be employed for boring almost any kind of material.

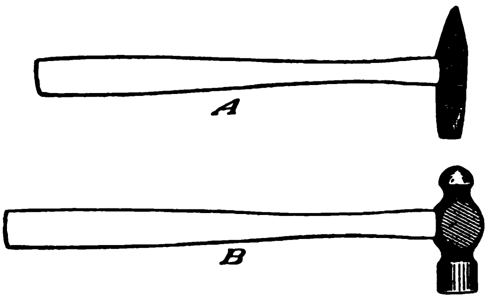


Fig. 8.—Riveting hammers: *A*, ordinary riveting hammer; *B*, machinist's hammer.

Riveting hammer.—A good riveting hammer is essential on every farm where modern machinery is used. There are two types of riveting hammer in general use (fig. 8), one having one end of wedge shape and the other type (known as a machinist's hammer) having a round end for riveting purposes. The hammer having the wedge-shaped riveting end is generally considered best for farm purposes.

Monkey wrench.—A monkey wrench frequently accompanies one or more of the farm machines, but as this is one of the most important repair tools an extra one will not come amiss. The size of this tool is determined by its length in inches, a 12-inch monkey wrench being adapted for most purposes. The type of wrench having the wood handle in two parts and riveted to the central iron handle is most serviceable. A 12-inch monkey wrench will cost about 60 cents.

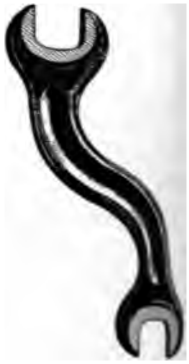


Fig. 9.—Solid, or S wrench.

Solid or end wrenches.—For many purposes the solid type of wrench (fig. 9) with end jaws fitted to the various sizes of bolts and nuts is desirable. Those made somewhat in the shape of the letter **S** are adapted to working in close places and are not likely to slip. These wrenches may be purchased at prices ranging from 7 to 35 cents each, or they may be made from steel and slightly hardened.

Alligator wrench.—The alligator wrench is very desirable for holding a round-headed bolt or rod of iron; also for turning nuts that are inaccessible for an ordinary wrench. Alligator wrenches having aw adjustable are obtainable, but the form having both jaws is somewhat cheaper. The cost of a small alligator wrench be anywhere between 15 and 60 cents, according to quality and ı.

›e **wrench.**—A pipe wrench of 10-inch or 12-inch size is quite able for use in making repairs upon farm machinery. The pipe ch (fig. 10) is adapted for turning or holding iron pipe, rods, ›lts. It is essential to have one or more pipe wrenches on farms e a water supply under pres- and general plumbing appli- s are maintained; however, ches for pipe fitting should rule be somewhat larger than used for repair work on ma- ›ry. The cost of a small pipe wrench suitable for repair work ld be about $1. Neither the pipe wrench nor the alligator wrench ld be used extensively for turning the nuts of bolts, as the teeth ese wrenches tear and injure the nuts.

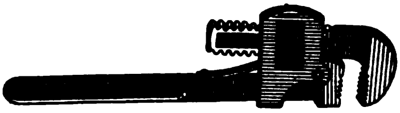


FIG. 10.—Pipe wrench.

nches.—An assortment of punches, including several sizes and s, should be kept on hand. The round, solid-point punch, ted to such work as punching out the rivets of the ordinary ing-machine knife, is the most important, although those having re and taper points are frequently required. The collection ld include a center punch having a blunt, sharp point for mark- netals before drilling.

ı assortment of punches may be purchased at a cost of from 40 cents each, or they may be made from tool steel by a black- ı.

d chisels.—For general-purpose repairing an assortment of vari- izes of cold chisels should be kept on hand. These tools belong e same class as the punches and can either be purchased or made tool steel. The cost of cold chisels varies according to the ınt of steel that they contain, the smaller ones being sold as low cents and the larger ones from 40 to 60 cents.

chisel for use in cutting hot iron known as a " hardie " (shown lace on anvil, fig. 12) is designed to fit the square hole in an l, the iron being laid upon the upturned edge of the hardie and k with a heavy hammer. Another type of cutter fitted with a le is offered by the trade. In using this tool the iron is placed the anvil, the cutter is held in position, and the cutting is done riking with a sledge or heavy hammer. The cutting edge of any l for cutting iron requires to be tempered very carefully in order it may withstand hard usage.

Files.—Both flat and three-cornered files will be required quite frequently in making repairs or improvements to equipment. A large flat file can be secured for 30 or 40 cents, and the small three-cornered ones will cost only 10 or 15 cents each. In securing a large flat file it is desirable that it should not be too fine, one of the flat bastard type being the most serviceable. The three-cornered files can be secured with single or double cutting ends. Square and round, or rat-tail, files are useful for many purposes.

Forge.—There are numerous makes of portable forges on the market, practically all of which are adapted to use on the farm. This type of forge is desirable where it is necessary to do work in several localities; but where the repair work can all be brought to a central shop a stationary forge with rotary blower will be found most satisfactory. Portable forges (fig. 11) can be secured at prices ranging from $3.50 to $15, a good outfit being obtainable for about $8. A blower with connections for a stationary forge can be bought for $10 to $15.

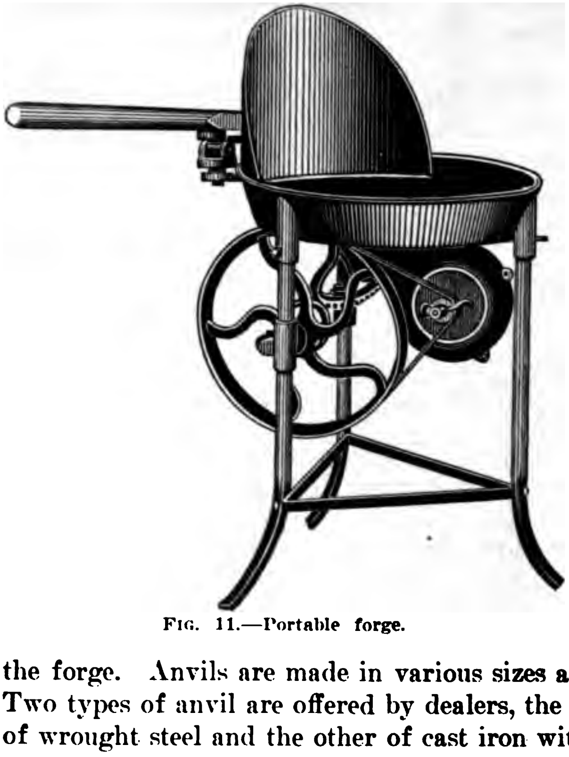


FIG. 11.—Portable forge.

Anvil.—Some form of anvil is of as much importance as the forge. Anvils are made in various sizes and are sold by weight. Two types of anvil are offered by dealers, the one consisting entirely of wrought steel and the other of cast iron with a steel facing. The wrought anvil, although more expensive, is to be preferred to the cast-iron type, as there is no danger of its breaking under heavy forging. An anvil suited to repair work should weigh from 70 to [illegible] pounds. The cost of a cast anvil will be about 3 cents a pound and of the wrought-steel anvil 10 or 11 cents a pound.

Where no regular blacksmith outfit is maintained, a combination vise and anvil will be found fairly satisfactory. The anvil should be mounted on a heavy block of wood, but in order that it may be moved when necessary it should not be anchored to the floor.

Blacksmiths' hammers.—A forging hammer weighing about 2 pounds will be desirable for working hot iron on the anvil. This tool will cost from 80 cents to $1.

Where considerable heavy ironwork is to be performed, it will be desirable to secure a sledge hammer weighing about 8 pounds, to be used by the person assisting the blacksmith. This tool is known as a "striking" hammer. The cost of an 8-pound sledge complete with handle will be about $1.

Tongs.—At least two pairs of tongs will be required for blacksmith work. If more than two pairs are provided the collection should include those having broad, flat jaws, also straight and curved-lip tongs. The size of tongs is determined by their length in inches, the 20-inch length being about right for general purposes. The cost of tongs of this character should not be more than 50 cents a pair.

Vise.—Where considerable forging is to be done a regular blacksmith's vise with wrought-steel jaws is desirable. This type of vise will withstand the heavy hammering necessary to the bending and shaping of iron. For general purposes the cast-iron type known as a bench vise will answer, and this can be procured at a much lower cost than the regular steel vise. A combination pipe-holding and bench vise can be obtained, but the cost of such a tool is almost as great as for both a bench vise and a pipe vise when made separately. A very fair bench vise can be secured for $3.50, a wrought-steel blacksmith's vise will cost about $5.50, and a pipe vise that will hold all sizes of piping from 2-inch down to the smallest can be obtained for $3.

Combination tools (fig. 12) intended to do the work required of a vise, anvil, and drill press are upon the market, but the separate tools will always be found most convenient and durable. A combination tool of this character can be obtained for about $4.

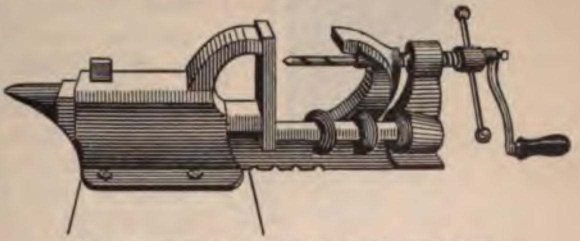


FIG. 12.—Combination vise, anvil, and drill.

Drill press.—Where extensive repairs are to be undertaken, there is no part of the repair outfit more desirable than a good drill press. The possession of some device by the use of which bolt and rivet holes may be drilled in metals renders possible the repair of almost any broken part of an implement. There are several forms of drilling machines upon the market, but a standard drill press (fig. 1 will prove most satisfactory. A machine of this class is suitable : all ordinary purposes and can be secured, exclusive of drills, : about \$10. There is a great difference in the quality of drills, bu fairly good set including $\frac{3}{16}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{7}{16}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, and 1 inch sizes can secured for about \$5, making the price of the whole outfit \$15. lower priced outfit is obtainable, but the drill press is a mach which with proper care should last a long time, and it pays to sec a good one.

As a rule the drill press is designed for mounting on a solid p preferably a support of the build in which the shop is located. In erating the drill press place a sn block of wood upon the bedplate : beneath the metal to be drilled. fore starting to turn the drill see tl its point is in the center-punch ma which indicates the location wh the hole is to be drilled, and t everything is both level and so The drill should be turned slowly a fed downward with regularity. C must be taken when the drill bre through the metal that the drill it does not bind and become brok When drilling holes in pieces of me that are too short for holding fir with the hand, a clamp should be u and the piece of metal fastened fir to the bedplate.

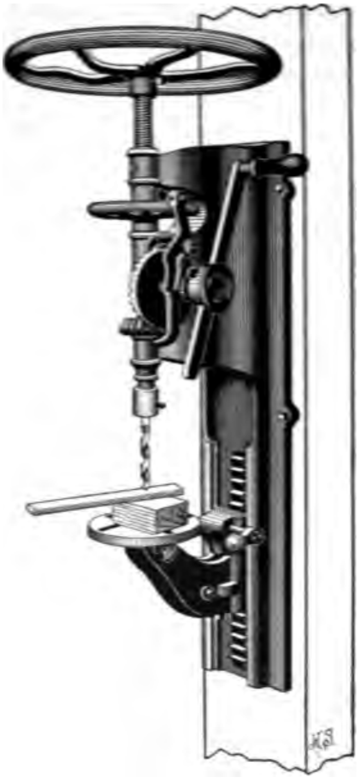


FIG. 13.—Standard drill press.

No one except an expert at grind should attempt to sharpen the dri as they must be ground to a partic bevel in order to cut properly. It best to take them to a machine sl from time to time and have th dressed. Certain drills, such as $\frac{1}{4}$, $\frac{3}{8}$, and $\frac{1}{2}$ inch, are used more of than the others, and it is desirable to have extra drills in these si on hand.

In boring wrought iron or soft steel plenty of good oil should be u upon the drill to prevent its heating. Hard steel should not be drill or at least not without first removing the temper. Cast iron, bra and composition metals can be drilled without the use of oil. Alwa ake an indentation with the center punch before starting to drill hole; this provides a starting point for the drill and insures getting the hole in the proper place.

Ratchet drill.—The place of a drill press may in a measure be filled by the employment of a ratchet drill (fig. 14). This device has the advantage of being portable, and it may also be worked in close quarters where the use of a drill press would not be practicable. In using a ratchet drill as a substitute for the drill press it will be necessary to provide a solid frame for holding it, as shown in figure 14. A common boilermaker's ratchet is obtainable for $4 or $5, but the square-shank drills for use with it are more expensive than the common round and taper-shank drills used in the drill press. The ratchet-drill outfit is not adapted for boring holes that are below three-eighths inch in size, owing to the liability of breaking the drills.

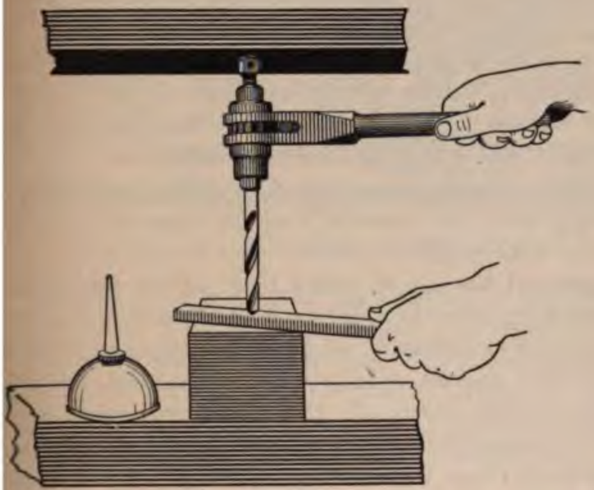


FIG. 14.—Ratchet drill.

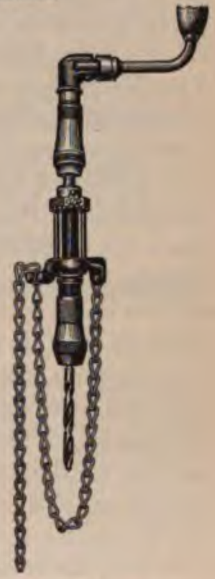


FIG. 15.—Chain drill.

Chain drill.—A small chain drilling outfit which works in an ordinary carpenter's brace is desirable for light work. This device is especially adapted to the drilling of tire-bolt holes and similar work not exceeding three-eighths of an inch in diameter. An outfit of this kind, as shown in figure 15, will cost about $2 exclusive of drills.

Twist drills.—Regular drills for use in boring metals can be secured having square shanks that fit in an ordinary carpenter's brace. These drills are adapted for boring either wood or metals, and are much more durable for rough work than are the regular wood-boring bits. Twist drills for use in a brace are especially desirable in the smaller sizes. The cost of these drills is from 10 cents upward, according to size and quality.

Hack saw.—Under ordinary circumstances a bar or rod of iron can be cut evenly enough with a hammer and cold chisel, but where exactness is required a hack saw (fig. 16) will be found desirable. As the little blades for cutting iron are very hard and brittle, it is necessary to set them firmly in the frame in order that there can be no chance of bending or buckling. In sawing iron, proceed as in sawing wood, except that slight pressure should be applied in the cutting direction only. The hack saw should be held firmly with both hands and a uniform movement of about 60 strokes a minute maintained. When the blade becomes worn or broken it may be replaced by a new one. The blades cost 8 to 10 cents each, and extra ones should be kept constantly on hand.

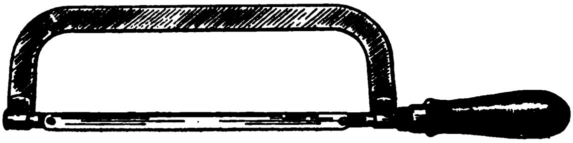


FIG. 16.—Hack saw. The thread for tightening the blade is located in the handle.

Soldering irons.—For general purposes a 1¼-pound soldering iron will be found satisfactory. Where continuous work is to be performed two irons are necessary, in order that one may be heating while the other is in use. Soldering irons should be heated only in a clear charcoal fire or in a blue flame of gas, gasoline, or alcohol. Before using a soldering iron it is essential that the tapering copper point be filed or ground until bright, and then coated with solder by first dipping the brightened hot point into a little of the soldering acid and afterwards rubbing over the solder. This process is known as "tinning" the iron, and is necessary in order to make the solder adhere to the copper and spread evenly. The iron must be retinned as often as the coating burns off. Soldering irons are sold by the pound, the price depending upon the market price of copper; however, the ruling price is about 40 cents a pound.

Thread-cutting appliances.—A set of stocks, dies, and taps for cutting threads on bolts and inside of nuts is quite desirable. This combination is termed a "screw plate" (fig. 17) and ordinarily includes all sizes from one-fourth inch to 1 inch. The prices of these tools vary according to make and number of pieces in the set, but a very good outfit can be secured for $8 or $10.

A cheaper device, known as a blacksmith's stock and dies, may be secured for $2.50 or $3, but is not as satisfactory as the regular screw plate. In selecting a thread-cutting outfit care should be taken that the pitch of thread corresponds to that used on standard bolts and nuts.

Pipe-fitting appliances.—With improved water-supply and plumbing fixtures it is possible for farmhouses and adjacent buildings to be uipped with modern conveniences. The work of installing the umbing fixtures can all be done by the aid of a set of tools adapted handling pipe and fittings. A set of pipe-fitting tools is essential the employment of pipes in the installation of modern sanitary tures in dairy barns. A complete outfit for cutting, threading, and rking pipe in sizes varying from one-fourth to 1 inch will cost

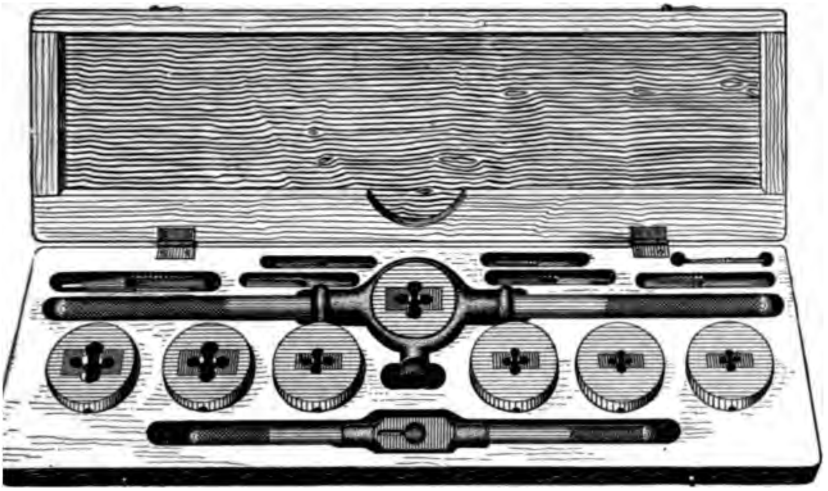


FIG. 17.—Screw plate.

out $10 for the simpler kinds of tools, and these answer every re-irement. This outfit would include stocks and dies, a pipe cutter, pipe vise, and two wrenches. It should be borne in mind that in ating the sizes of pipes the inside, instead of the outside, diameter is iven. The thread used on piping is different from that employed on lts; consequently the dies for one are not adapted to threading the ther.

MISCELLANEOUS TOOLS.

There are a number of tools adapted to the handling of both wood d metals required in general repair work about the farm.

Tinners' snips.—A small pair of tinners' snips, or shears, is desirable r cutting all kinds of sheet metals that may be required either for pair or construction work. The size of these shears is determined the length of their jaws in inches. A 2½ or 3 inch size is desirable d should cost between $1 and $1.50.

Small vise.—A small bench or table vise having about a 2½-inch jaw useful for many purposes, especially where the objects to be held e quite small. This tool is also desirable for mending harness in se a regular harness clamp is not available. A vise of this character will cost all the way from 50 cents to $1.50, according to size and quality.

Dividers.—The little implement known as dividers, or compasses, is desirable for drawing circles or segments of circles in the making of special parts of machinery from wood. The cost of a pair of dividers with a segment and set screw for setting to any angle should not be more than 60 cents.

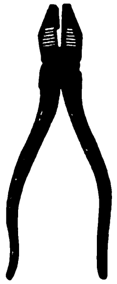


FIG. 18.—Pliers.

Pliers.—Some form of pliers for working wire is essential. Besides their use for handling wire a good pair of pliers is desirable for a great many lines of repair work. There are a number of styles of pliers on the market, but one of the simpler types (fig. 18) will give the greatest amount of service. As a rule a very serviceable pair of pliers can be secured for about 60 cents.

Cutting nippers.—A pair of heavy cutting nippers with circular jaws is useful for many purposes, especially for removing a shoe from the foot of a horse or for trimming the edge of a broken hoof. Where a horseshoeing outfit is maintained, the cutting nippers will be included.

Crowbar or pinch bar.—A crowbar or pinch bar will be found useful on the farm for prying or moving heavy objects. Where stones are to be removed from the soil a bar of this character is almost indispensable. A bar for general purposes weighing about 20 pounds will cost from $1 to $1.50.

Maul, or beetle.—A maul, or beetle, can be hewn from a gnarly piece of hickory or gum. The head portion of the maul should be about 9 inches in length and 6 or 7 inches in diameter. Through the middle of this block a hole about 1½ inches in diameter is bored and a shaved hickory handle inserted, forming a mallet weighing 16 to 25 pounds. If extra-heavy work is to be done, the head can be reenforced by means of iron rings, which are put on while hot and shrunken into place. This tool is desirable for driving heavy stakes and similar work.

Grindstone.—The farm repair outfit will not be complete unless some form of grindstone is included. The old type of stone with its wooden shaft, crank, and bearings has largely been replaced by the light-running treadle grindstones. No part of the repair work is so important as the keeping of tools in good order, and proper facilities for sharpening are essential. A good stone, mounted ready for use, will cost about $3.50.

Oilstone.—The oilstone is a necessary adjunct to the grindstone, its use being to put a smooth edge on the tools after grinding. Chisels, [illegible] of planes, and similar tools require grinding only occasion-lly, but may be sharpened quite frequently on the oilstone, and a ne cutting edge maintained. Instead of water, use kerosene or any ght oil on the oilstone and wipe off clean when through sharpening. Oilstones can be bought at prices from 60 cents to $1.

Oiler, or squirt can.—This device is a convenience about the shop, both for oiling machinery and for keeping tools in order. A small oiler is desirable for use in connection with the oilstone. A can of this character will cost from 10 to 40 cents according to quality. In purchasing an oiler care should be taken to secure one having a folded seam where the bottom is joined to the main portion, as a soldered seam is liable to give out in a short while. It is also essential that the bottom should have plenty of "spring" to force the oil from the spout.

Wire stretcher.—On farms where wire fencing is employed it will be necessary to provide an appliance for stretching lines of wire. For light work, where short runs of single wire are to be handled, one of the hand-lever stretchers will be found most satisfactory. This tool consists of a wood lever about three feet in length, about one-third the distance from one end of which is attached a pair of grips or pliers to hold the wire. The wire is gripped in the holder, the short end of the lever passed around the post, and the power applied to the handle. A stretcher of this type can be purchased for about 75 cents.

Another form of stretcher consists of a wire grip to which is attached a ring through which an ordinary crowbar may be passed to serve as a lever. This type of grip is obtainable for about 50 cents.

Staple puller.—A staple puller is essential to the repair or alteration of wire fencing. An old mower guard will serve for this purpose, but a more satisfactory device may be constructed from a piece of $\frac{3}{4}$-inch steel rod, about 15 inches in length, by drawing one end to a point, then turning about $1\frac{1}{2}$ inches of this point at a right angle to the main portion. In using this tool the point is driven behind the staple by means of a hammer, then by a prying movement the staple is easily drawn. The handle end of the clawbar (fig. 4) may be shaped for use in drawing staples.

HARNESS-REPAIR OUTFIT.

The tools and facilities required for keeping harness in repair are comparatively simple and inexpensive. Many of the parts of harness, together with convenient supplies with which to make repairs, are now offered at reasonable prices by dealers everywhere. A considerable portion of the repair work on harness can be performed by the aid of tools required for other purposes, but there are a few special devices that are desirable.

Leather punch.—A good leather punch is one of the most desirable implements both for repair work and for making alterations in harness to fit animals of different sizes. A leather punch made somewhat on the order of a pair of pliers and having four or more punching tubes of various sizes is most desirable. It can be secured for about 40 cents.

Rivet set.—A rivet set is especially desirable for use in connection with solid copper or coppered steel rivets. This (fig. 19) is made of a small piece of tool steel and is provided with a small hole for driving down the washer on the rivet, also a countersink for expanding the end of the rivet.

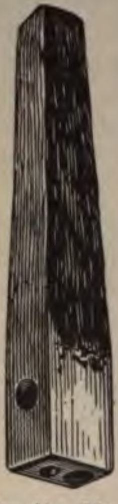


FIG. 19.—Rivet set.

Riveting machines.—There are upon the market several kinds of lever devices for use in the insertion of hollow or tubular rivets in leather. These riveting machines are comparatively cheap, but as a rule the hollow rivets do not hold so well as the solid rivets.

Awls.—For the repair of driving harness there should be kept on hand one or two awls to be used in making the holes for sewing with a waxed thread. Awls of this character can be purchased for about 10 cents each, including handle.

Harness clamp.—A clamp of some character is desirable for holding parts of harness while repairs are being made upon them. For this purpose a small table vise may be employed or a regular steel or wooden clamp may be purchased. A very serviceable homemade clamp may be constructed from two pieces of wood shaped somewhat like the staves of a barrel; at one end these pieces are dressed off so that they will fit together like the jaws of a vise, and the opposite ends may be hinged together or they may be fastened firmly to the sides of a base block. A short distance from the clamping end a screw, a bolt, a leather strap, or some other simple device may be used to draw the jaws tightly together.

SPECIAL CONVENIENCES.

In addition to the outfit of tools obtainable from a hardware dealer, there are a number of special devices that may be made on the farm and which will prove of great assistance in general repair work. Among the more important are the following:

Workbench.—A workbench of some kind will probably be the first essential. A good type of workbench is shown in the foreground of figure 21; also in cross section in figure 20. For the construction of this bench there will be required four boards seven-eighths inch thick, 12 to 14 inches wide, and about 12 feet in length. The length of the bench, however, will depend upon the size of the shop or other space that may be available for use as a workroom. Two pieces of 2 by 4 ch scantling, each 16 feet long, will be sufficient to construct the amework of the bench. All lumber entering into the construction the workbench should be thoroughly seasoned and dressed to iform width and thickness.

A clamp for holding materials should be constructed from a piece hard wood and attached by the aid of a carpenter's bench screw, as own in cross section in figure 20. This clamp should be provided ith notches or pin holes at the lower end, so that it can be set to ld materials of any thickness. Along the front of the bench, two three holes should be provided, into which pins may be set for pporting boards or other materials that are too long to be held gid by the clamp alone.

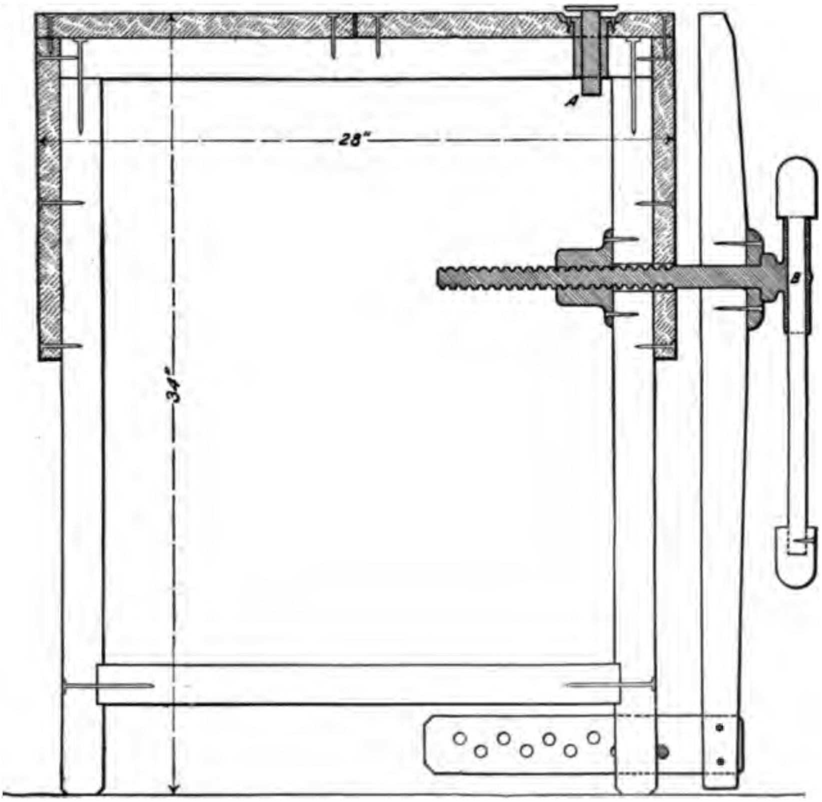


FIG. 20.—Cross section of workbench: *A*, planing stop; *B*, bench screw.

A "stop" for holding materials that are to be planed can be serted in the top of the bench, near the left-hand end, as shown in gure 20. If a regular stop is not employed, its place may be taken y a small piece of notched board nailed on top of the bench.

Sawhorses.—A pair of trestles, or sawhorses, each consisting of a iece of 2 by 4 inch or 2 by 6 inch timber, about 4 feet in length, supported upon four legs, as illustrated in the foreground of figure 21, are very convenient for working upon while marking, sawing, boring, or chiseling. The sawhorses are an accessory to the workbench and should be constructed at the same time. The cost of materials with which to construct both the workbench and sawhorses should not exceed $5.

Miter box.—Among the accessories to the workbench there is perhaps no device that will give greater satisfaction than a good miter box to be used for sawing small wood materials either square or at an angle. For the construction of a miter box, three pieces of board 1 inch thick, 6 inches wide, and 3 feet in length should be selected and nailed together in the form of a square trough, taking care that the nails are driven well out toward the edge of the boards. Vertical cuts are sawed down through the sides to the bottom board to guide the saw when the box is in use. Near one end a cut is made at right angles with the length of the box to be used in making square cuts. For making bevel cuts for a right-angled miter joint, the sides of the box should be sawed down on oblique lines running at an angle of 45 degrees with the length of the box. Two such cuts should be made and should cross each other at the middle of the box, forming a letter X. In marking the box to make these cuts, the square should be laid flat on top of the box so that its corner is flush with the outer edge on one side, and each arm reaching obliquely across the box will show exactly the same number of inches to the outer edge on the other side. When the square has been correctly placed, mark along one arm for one of the cuts; then reverse the position of the square and mark for the other cut. A miter box is shown on top of the workbench in figure 21.

COMBINATION TOOL OUTFITS.

For the benefit of those contemplating the purchase of tools for use on the farm the following combinations are suggested. In making up these lists of general-purpose repair tools the better grades have been placed in the higher priced sets, although those included in the cheaper outfits should be of good and durable material.

A $2.50 outfit.—A hatchet, a handsaw, a small square, a screw-driver, and a pair of pliers.

A $5 outfit.—A hatchet, a 26-inch handsaw, a small steel square, a drawing knife, a brace and four bits (¼, ½, ¾, and 1 inch), a pair of pliers, a screw-driver, a cold chisel, a flat file, and a monkey wrench.

A $10 outfit.—A hatchet, a hand ax, a 26-inch handsaw, a 24-inch steel square, a drawing knife, a brace and six bits (¼, ⅜, ½, ⅝, ¾, and 1 inch), a pair of pliers, a screw-driver, a cold chisel, a 12-inch flat file, a monkey wrench, a jack plane, 2 chisels (½ and 1 inch), a rivet punch, a riveting hammer, a leather punch, and a small oil can.

**A $15 outfit.**—An ax with handle, a hand ax, a hatchet, a 26-inch andsaw, a 24-inch steel square, a drawing knife, a brace and six bits ¼, ⅜, ½, ⅝, ¾, and 1 inch), 3 twist drills ($\frac{3}{16}$, ¼, and ⅜ inch, with square hank to fit in carpenter's brace), a bit gimlet, a screw-driver, a jack plane, a pair of pliers, 2 chisels (½ and 1 inch), an auger (1½ inch, with handle), a small vise, a cold chisel, a monkey wrench, a rivet punch, a claw hammer, a riveting hammer, a leather punch, a compass saw, a spirit level, an oil can, a 12-inch flat file, a 12-inch wood rasp, 2 small three-cornered files, a 2-foot folding rule, a chalk line, and a ball of chalk.

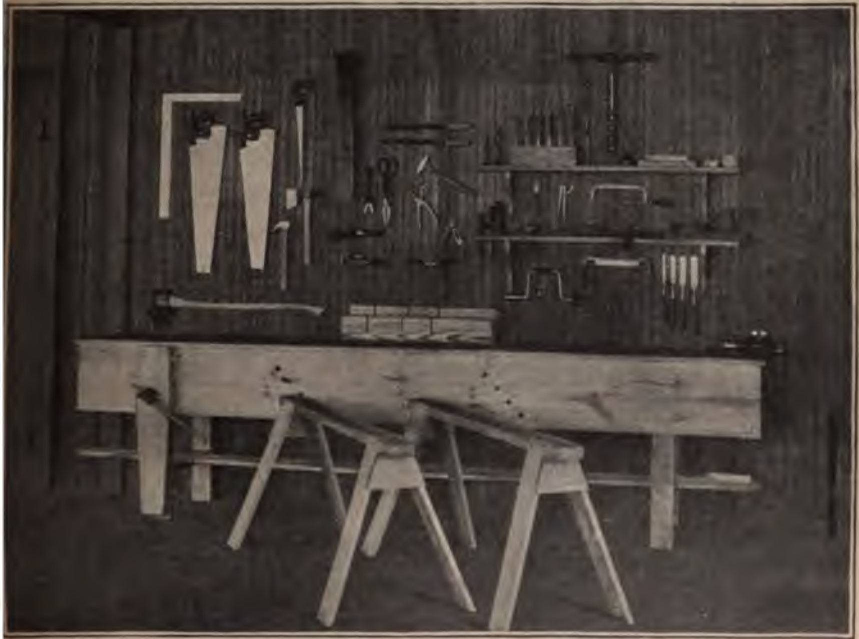


Fig. 21.—Interior of workshop with $25 outfit of tools, a workbench, sawhorses, and miter box.

A $20 outfit.—To the list given for the $15 outfit, add the following: A 26-inch ripping saw, a spokeshave, a bevel square, a scratch gauge, a pair of dividers, a small try-square, a scratch awl, 2 twist drills (½ and ⅝ inch), an oilstone, and a pair of soldering irons.

A $25 outfit.—To the list given for the $20 outfit add the following: A small steel square, an alligator wrench, a hack saw, a 10-inch pipe wrench, a pair of tinners' shears, a ratchet brace instead of a plain brace, a rivet set, additional bits to make a full set of 12 (¼ inch to 1¼ inches by eighths and sixteenths), and a smoothing plane. A $25 outfit is shown in figure 21.

IRON-WORKING AND SHOP EQUIPMENT.

Blacksmithing tools.—A blacksmith's outfit adapted to the requirements of a large farm should include a forge, an anvil, a 2-pound hammer, an 8-pound sledge, a riveting hammer, two pairs of tongs, an assortment of punches, hot and cold chisels, anvil hardie, cutting nippers, coarse files, screw plate, vise, drill press with drills, and a monkey wrench. The cost of this outfit may be as low as $30 or as high as $60 and upward, according to the class of materials selected. "Combination outfits" consisting of the above tools are offered at these prices, but if the outfit is made up by selecting from the general stock of a dealer, the price paid will be much greater.

Shop equipment.—The complete equipment of a shop for the making of general farm repairs should include the above blacksmithing outfit, the $25 collection of wood-working and general-purpose tools, a pipe-working combination, miscellaneous tools, harness-repair outfit, a workbench, a pair of sawhorses, and a grindstone. This entire equipment for a shop can be secured for about $100 in a fair quality of goods, and for $150 tools of excellent quality can be obtained.

SHOP FACILITIES FOR REPAIR WORK.

A shop or other suitable place where repair work can be carried on during cold or stormy weather is almost as important as the tools and materials with which to make the repairs. A small building devoted exclusively to shop purposes is desirable, but where this is not available a portion of one of the regular farm buildings may be utilized. One side of a wagon shed can frequently be devoted to this purpose. A workbench can be fitted up and provision made for the care of tools and supplies.

Plan of workshop.—A shop which meets the requirements of the general farm is illustrated by the floor plan shown in figure 22. The shop from which this plan was taken consists of a one-story building about 24 feet in length and 16 feet in width, having a plank floor over about two-thirds of its area, the remainder with an earth floor being used as a blacksmith shop. The floored portion was provided on the one side with a wood-working bench, over which were placed several shelves for the reception of tools. On the opposite side there was provided a heavy plank bench with a vise and other equipment for working iron. Below the iron-working bench there should be provided a rack upon which to store the stock of various sizes of square and round iron required for making repairs. Above the iron-working bench there should be a few shelves for the storage of tools; also numerous pigeonhole boxes for the accommodation of the stock of bolts, nuts, and washers.

This shop was constructed of cheap lumber, the siding being put on up and down with cracks battened, and it has a simple gable roof. By this type of construction ample space is secured overhead for the storage of materials, especially seasoned timber for use in making repairs. An abundance of light is essential to good work, and as much of the repair work will be done during dark and cloudy weather, the windows should be numerous and so distributed as to provide for uniform lighting. The windows should be protected on the inside by wire netting.

The large doors in the end of the shop are made to cover the entire space between the workbenches, so that the larger farm implements may be brought upon the floor for repairing. Where the climate is cold, provision should be made for a heating stove, in order that the shop may be comfortable for work during winter weather.

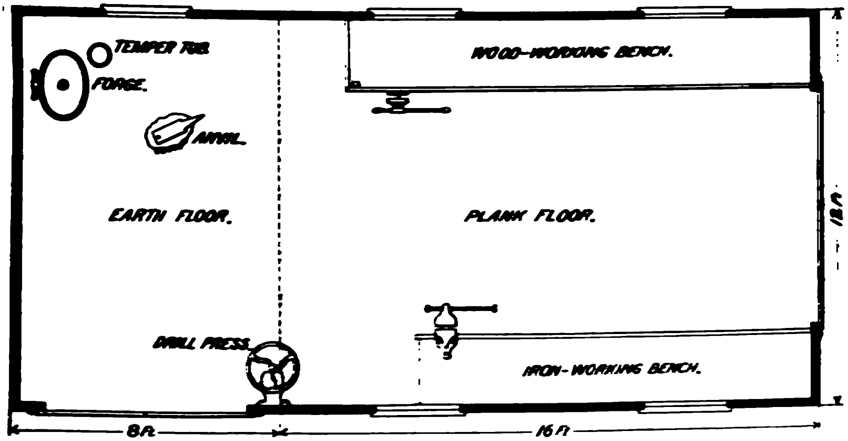


FIG. 22.—Floor plan of workshop.

If a portion of a wagon shed or other farm building is set aside for shop work, it should, so far as practicable, be fitted up the same as a regular shop.

The care of tools.—The system of storing the tools should conform to the needs of those using them and to the work to be performed. In many instances it may be desirable to keep the tools in a portable chest in which they may be carried to any part of the farm or plantation; on the other hand, if the work is done almost entirely at the shop the tools will be more accessible when supported on the walls or upon shelves above the bench.

In climates where the atmosphere is moist the greater part of the time, it is not wise to keep the tools exposed by hanging them on the walls or laying them upon open shelves, but a wall cabinet or a tool chest should be provided. It should be the aim to have a place for every tool, and then cultivate the practice of returning it to its proper place immediately upon the completion of the work in hand. A very good plan for keeping the tools in their respective places is to first draw an outline of each tool in its place upon the wall and then paint this space black or some color in contrast with the wall itself, so that when any tool is not in its place its absence will be readily apparent.

Many persons are in the habit of leaving tools where they finish using them. In the first place, a tool can not be kept in working condition if allowed to remain exposed to the weather, and in the second place the time lost in locating the tool when it is next required for use will be much greater than that which would be required to return it to the proper place.

MATERIALS REQUIRED FOR GENERAL REPAIR WORK.

However complete the tool equipment, it will be of little use without a supply of materials with which to replace worn or broken parts of machinery and implements. The time required to secure stock materials may be as great as that necessary to have the repairs made in the nearest shop. A supply of timber, bar iron, bolts, rivets, screws, etc., should be kept constantly on hand and renewed from time to time as the stock runs low.

WOOD MATERIALS FOR REPAIRING FARM EQUIPMENT.

The supply of wood for use in making repairs should be well seasoned and dry. It should include split hickory, ash, and oak, from which handles, singletrees, doubletrees, neck yokes, and similar articles can be made. Split timber is better than sawed for these purposes, owing to the straight grain when the wood is split. Sawed oak, ash, or heart pine, in sizes 1 by 2, 2 by 4, 2 by 6, 3 by 4, 3 by 6, 4 by 4, and 4 by 6 inches, and 14 or 16 feet in length is frequently required for use in replacing broken handles, braces, tongues, axles, etc. It is also desirable to have on hand a small stock of white pine, one-half and seven-eighths inch in thickness, for use in repairing or replacing the lighter wood parts of implements.

A great variety of wooden parts for farm implements is kept in hardware and general supply houses. On large farms it is advisable to keep on hand one or two each of the following: Ax handles, hatchet and hammer handles, hoe and rake handles, fork handles, shovel handles, singletrees and doubletrees, wagon tongues, carriage poles, and buggy and wagon shafts.

It should be the practice to save every small piece of good material nd store it in a dry loft or other convenient place. A good piece of thin board can frequently be saved from a broken packing box, and his will serve as well as new material for repair work. It should be he policy to save every good barrel hoop or extra barrel head for uture use in replacing a broken or missing one. Very little time will e required to care for these articles if some system of storing them s employed.

METAL MATERIALS FOR REPAIRING FARM EQUIPMENT.

Bar Iron.

Where a regular blacksmith outfit is maintained the supplies kept n hand should include a stock of both round and square iron. The ars come in lengths of about 14 feet.

Round iron bars.—The stock should include the following: ¼, ⅜, ½, ⅝, and ¾ inch, three to five bars each, and one bar 1 inch in diameter. The ⅜ and ½ inch sizes are most frequently needed.

Rectangular iron bars.—The stock should include the following sizes: ⅛ by ¾ inch, ⅛ by 1, ¼ by 1, ¼ by 2, ⅜ by 1, ⅜ by 1½, ⅜ by 2, ½ by 1, ½ by 1½, ½ by 2, and ½ by 3 inches. The greatest demand will be for ¼ by 1 inch, ¼ by 2, ⅜ by 1½, and ½ by 2 inches, and of these sizes three or four bars should be secured. Of the other sizes one or two bars will usually suffice.

T-bars and angle iron.—These in sizes up to 2½ inches are very useful for making repairs on harrows, cultivators, and other implements in the construction of which such iron has been used.

The price of bar iron varies with the market, but it is usually less than $3 per hundredweight.

Iron Bolts.

For the convenience of intending purchasers, a list of bolts is given. The sizes most needed in repair work are indicated by the larger numbers suggested. For information concerning prices, dealers or their catalogues should be consulted, as the prices vary with locality and market conditions. Bolts, screws, and rivets can be secured at a great reduction if purchased in original packages containing 50 or 100, or a gross, as the case may be.

Carriage bolts.—As a rule the round-headed or carriage type of bolt is best adapted for use in wood or where wood and iron are bolted together. Whenever a nut is being drawn down upon wood, a washer should be placed beneath it. A hole bored for the insertion of a carriage bolt should not be more than one-sixteenth inch larger than the bolt, as the square shank of the bolt should be driven solidly into the wood to prevent its turning. The difference between machine and carriage bolts is shown in figure 23.

The supply of carriage bolts should include the following: 100 each of ¼ by 2, ¼ by 3, and ¼ by 4 inches; ⅜ by 2, ⅜ by 3, ⅜ by 4, and ⅜ by 6 inches; ½ by 1½, ½ by 2, ½ by 4, and ½ by 6. Of the following sizes a dozen each should be secured: ½ by 8, ½ by 10, and ½ by 12 inches.

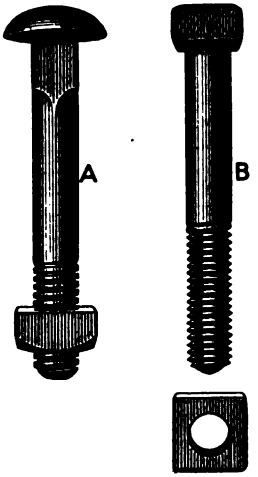


FIG. 23.—Bolts: *A*, carriage bolt; *B*, machine bolt.

Machine bolts.—These have square heads but the shanks are round throughout. For bolting together iron parts, they should always be used. The following will make a fair supply for a farm: 100 each of ⅜ by 2 and ⅜ by 4 inches; ½ by 1½, ½ by 2, ½ by 3, ½ by 4, and ½ by 6 inches; ⅝ by 2 and ⅝ by 4 inches. A dozen each of the following should be included: ½ by 8 and ½ by 10 inches; ⅝ by 6, ⅝ by 8, and ⅝ by 10 inches; ¾ by 3, ¾ by 4, ¾ by 5, ¾ by 6, ¾ by 8, ¾ by 10, ¾ by 12, and ¾ by 14 inches.

Tire bolts.—Bolts either $\frac{3}{16}$ or ¼ inch in diameter and from 1½ to 2 inches in length are most used. Examine the wheels of the vehicles which are to be kept in repair, and get two or three dozen of each size of bolts needed. A few felly plates should be included.

Extra nuts.—To replace lost nuts, the following should be included in the stock: 25 each of ¼, ⅜, ½, ⅝, and ¾ inch sizes.

Washers.—For use with bolts and rivets, get 2 pounds each of the ¼ and ⅜ inch sizes, and 5 pounds each of the ½ and ¾ inch sizes.

Rivets, Screws, Nails, Etc.

Iron rivets.—For most purposes rivets with small round heads or with broader flat heads are used. The sizes most needed are $\frac{3}{16}$ and ¼ inch in diameter and ¼, ⅜, ½, ¾, and 1 inch in length. From a half pound to a pound of each size will be an ample supply. Rivets with countersunk heads are used for some purposes, and a few of the different sizes should be secured; also a few of the special rivets used in repairing mower and reaper knives.

Wood screws.—Screws are classified by number and length, the number referring to the diameter. They are put up in boxes each containing one gross. A gross each of the following sizes should cost about $2, and will meet all ordinary demands: No. 6, of ¾ and 1 inch lengths: No. 8, of 1, 1¼, and 1½ inch lengths; No. 10, of 1¼, 1½, 1¾, and 2 inch lengths; and No. 12, of 2 and 2½ inch lengths.

Nails.—Of flat-head wire nails, 5 pounds each of 3, 4, 5, and 6 penny sizes and one keg (100 pounds) each of 8, 10, 20, and 40 penny sizes should be obtained. Nails purchased in small quantities will cost 4 and 5 cents a pound, but if secured by the keg the cost is generally below 3 cents a pound. For certain purposes, such as the laying of floors and the construction of partitions from matched lumber, the square cut steel nails are considered desirable. Wire brads of various sizes and lengths are useful for both repair and construction work, and a few of these of different sizes should be secured.

Staples.—Of the standard size used in the construction and repair of wire fencing, 10 pounds or more should be kept on hand; also a pound or two of the smaller sizes for fastening poultry netting. Small staples, known as "double-pointed tacks," are useful for tacking fly screen over windows and for many other purposes.

Strap hinges, clips, wire, tin, etc.—On farms that are at a distance from a hardware store, a few pairs of strap hinges of 3, 4, 6, 8, 10, and 12 inch lengths should be kept in stock. Hooks and staples or iron latches for fastening gates and barn doors may also be included in the hardware list. Clips for singletrees, doubletrees, and neck yokes are offered by dealers at prices far below the cost of having them made at a local shop. Other materials that may often prove useful are small copper wire, annealed wire, galvanized wire, hoop iron, galvanized sheet iron, and sheet tin.

SUPPLIES FOR REPAIR OF HARNESS, CARRIAGE TOPS, ETC.

Every farmer should have on hand supplies for the repair of harness, and many will find it an advantage to have also some materials for making the simpler repairs on carriage and buggy tops. Ready-made harness and bridle parts of all kinds can be secured from many of the larger establishments.

Harness rivets.—The solid rivets for harness repairs are either of copper or coppered steel, the former costing about three times as much as the latter. They can be bought in boxes containing assorted lengths ranging from one-fourth to three-fourths inch.

Leather.—By visiting a regular harness shop, it is often possible to secure at a small cost scraps of harness leather that will prove very useful in making repairs; but where the amount of repairing to be done is large, the purchase of a whole side of good harness leather is advisable.

Harness hardware.—The supplies of this class most often required are buckles of various sizes, snap hooks, bridle bits, hame staples, hame clips, cockeyes, open links, and rings of different sizes.

Other materials.—The outfit should also include thread, beeswax, extra awls and needles, carriage washers, knobs and eyelets for carriage curtains, shaft tips, and harness oil. A broken shaft may often be made good with a metallic shaft end. There are also on the market a number of devices, known as "menders," for making quick temporary repairs to harness.

PAINTS, OILS, AND MISCELLANEOUS SUPPLIES.

For repainting the farm equipment the following supplies will be found useful: White lead, red lead, Venetian red, raw linseed oil, and turpentine. Ready-mixed paints can be used, but when made of good materials they are more expensive. For lubrication purposes there should be a supply of machine oil, axle grease, and castor oil. For miscellaneous purposes there will be required small quantities of liquid glue, rubber cement, solder, soldering fluid (prepared by adding metallic zinc to strong hydrochloric or muriatic acid), sandpaper, emery cloth, and twine.

SUGGESTIONS.

The lists contained in this bulletin include many things that will not be required on a large number of farms. Where specialized farming is pursued, only the tools and supplies with which to repair the special farm equipment will be required. The indiscriminate purchase of tools may result in direct loss.

In deciding what tools and materials to purchase, always give preference to those most frequently and urgently needed, passing over those that will be rarely used.

Keeping a machine or vehicle in good repair and well oiled not only increases its efficiency, but lessens the power required in using it.

The proper maintenance of farm machines not only saves money but avoids danger to those who operate them. Keeping the harness and vehicles in repair may prevent a dangerous runaway.

So far as practicable let the repair work be done when regular farm work is not pressing, as on rainy days and during the winter season. Pursue the repair work as a kind of recreation or rest from the regular farm operations.

Do not have several places for the storage of repair tools and supplies. Have one convenient place, and see that all tools are kept there when not in use.

Tools and materials should be kept in their proper places. Do not keep all sizes of bolts or screws mixed together in a single receptacle, but fit up suitable boxes or bins, so that the supplies may be accessible on short notice.

Keep all tools clean and free from rust, and all edge tools sharp.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 348.

BACTERIA IN MILK.

BY

L. A. ROGERS,

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1909.

RD UNIVERSITY

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., December 5, 1908.

Sir: I have the honor to recommend that the accompanying paper “Bacteria in Milk,” by L. A. Rogers, of the Dairy Division of this ureau, be published as a Farmers' Bulletin. This paper appeared in e Yearbook of the Department for 1907, but owing to the demand r information such as it contains and to the widespread interest in e subject of wholesome milk I consider it desirable that it should issued in the Farmers' Bulletin series.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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BACTERIA IN MILK.

MILK—ITS COMPOSITION AND CHARACTERISTICS.

A study of the changes produced in milk by bacteria is a study of he decomposition of the constituents of milk. Many of these changes re so complex that they can not be discussed in a paper of this ature. The fats are usually little affected by the growth of bac-eria in milk. The sugar, on the other hand, is frequently fermented, nd various acids, gases, and alcohol may result. The casein and the lbumen are decomposed by many bacteria. The products of the ecomposition sometimes have sharp or disagreeable flavors and not frequently unpleasant odors.

It has been shown that milk contains certain digestive principles—e so-called unorganized ferments, or more properly enzymes—hich slowly digest the milk. Fresh milk, collected and held with-ut bacterial contamination, will spoil in time unless these enzymes re destroyed by heating.

BACTERIA—THEIR NATURE.

To understand the changes that take place in milk it is necessary to onsider briefly the nature of the minute organisms causing these hanges.

The basis of all life is the mysterious jelly-like substance to which cientists have give the name of protoplasm. In its various forms t constitutes the actual living, changing part of every living thing, lant or animal. The simplest living things are merely shapeless, aked masses of this protoplasmic jelly. Bacteria show the first dif-erentiation toward the complete plants with which we are familiar. he protoplasm is covered and held in definite shape by a very thin nd delicate wall. They are then tiny one-celled plants. The plants rowing in our gardens are made up of an infinite number of cells, rganized like the workers in a community, each kind doing a par-icular work and all necessary to the complete plant. In bacteria, owever, each cell is a complete plant in itself. (See figs. 1–4.) heir food must be in a condition to pass through the cell wall to the iving protoplasm within. It must be in solution in water and it must be diffusible—that is, it must be a substance that will pass through a membrane, otherwise it could not pass through the cell wall of the plant. Not all substances soluble in water will pass through a membrane. Thus albumen, while soluble, can not, as will be pointed out later, be used by bacteria until it has been changed.

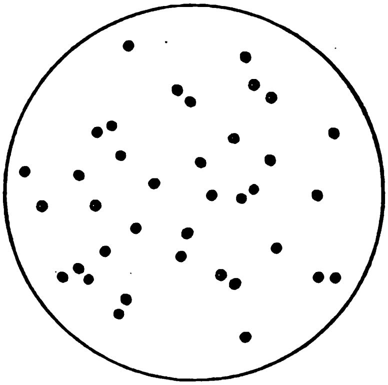


FIG. 1.—Bacteria of the spherical or coccus type.

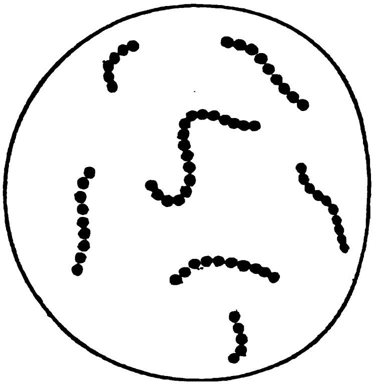


FIG. 2.—Bacteria of the coccus type hanging together in chains.

On the other hand, sugar is both soluble and diffusible and probably can be used for food by bacteria without previous change.

Through infinite generations of dependent existence bacteria have lost their ability to live independently and have become parasites or saprophytes. In other words, they are no longer able to elaborate their nourishment from the simpler compounds existing in the air and the earth, but must depend on higher, better organized plants or animals to prepare their food for them. Hence we find them living only where there are present at least traces of animal or plant tissue. If they depend on living tissue, they are called parasites; if they

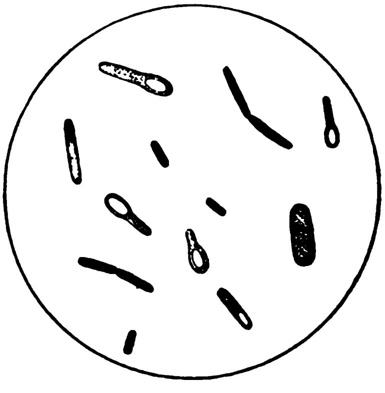


FIG. 3.—Typical rod-shaped bacteria (Bacillus type). In some of these spores are shown as clear areas.

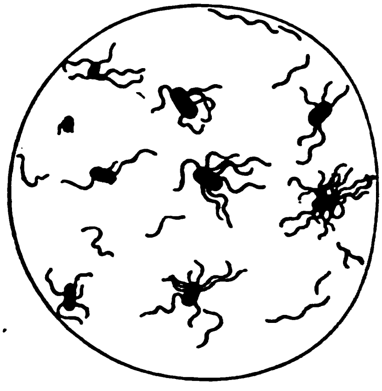


FIG. 4.—Bacteria with hair-like appendages which enable them to swim about in water or milk.

obtain their nourishment from dead, partly decomposed plant or animal matter, they are known as saprophytes.

The growing corn plant is so delicate that it is killed by a short exposure to a freezing temperature or to a scorching sun; yet the dried corn kernel will stand the most intense cold, long drying, or comparatively high heat, and when proper conditions are provided will grow. In a somewhat similar way some bacteria are provided with means of withstanding unfavorable conditions. These bacteria form a small round or oval body in the interior of the cell. When the bacterium dies, this spore, as it is called, is set free. Like the seeds of the higher plants, it is able to survive long drying and great extremes of temperature. To destroy spores by heat, it is necessary to expose them to long-continued boiling or for a short time to temperatures above the boiling point of water.

The bacteria are so small that it is difficult to form a conception of heir dimensions. It is only when we consider them in the aggregate hat they reach units of measure with which we are familiar. It is stimated that if 25,000 average-sized rod-shaped bacteria were placed nd to end their combined length would equal 1 inch. The weight of an verage bacillus is so small that it has been estimated it would take over 00,000,000,000 of them to equal 1 gram, or 16,800,000,000,000 to weigh 1 ounce.

What the bacteria lack in size is made up in their great numbers nd powers of reproduction. A cubic centimeter of milk, which contains about 25 drops, frequently contains thousands, sometimes milons, even hundreds of millions, of bacteria. A single drop of sour milk may contain 40,000,000 bacteria.

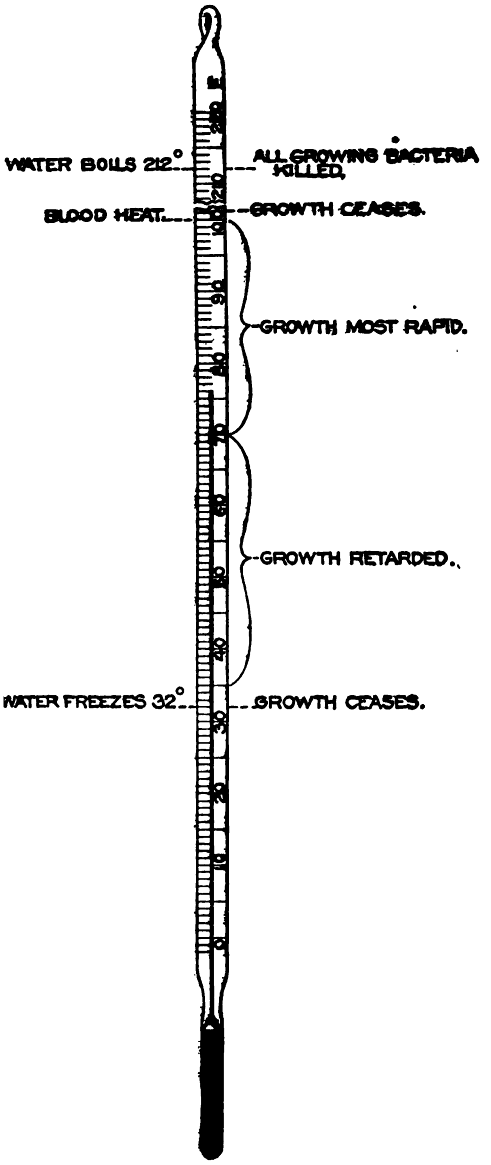
Bacteria reproduce themselves by a very simple process, known as ssion. The cell becomes elongated and a partition wall is formed cross the middle. The two cells thus formed separate, and we have wo bacteria. Higher plants may take weeks and months, or even many years, to grow to maturity. These simple plants known as bacteria, however, under favorable conditions may complete their growth and reproduce themselves in less than an hour.

Bacteria, in common with all other living things, obey certain fixed laws. Certain elements and certain combinations of elements are necessary for their growth. There seem sometimes to be exceptions to these laws, but closer study shows that these exceptions are only apparent.

It would be very easy for the layman to obtain the impression by reading popular descriptions that bacteria are peculiar and unusual plants, having little in common with other forms of plant life. On the contrary, bacteria, in their form, habits of growth, and life processes, closely resemble many other simple plants, like the algæ, the yeasts, and the molds.

RELATION OF TEMPERATURE TO GROWTH OF BACTERI

The relation of bacteria to temperature is most interesting a ortant. A certain amount of heat is essential and a certain a is fatal. Each part variety of bacteria l upper and a lower te ture limit beyond wl does not grow and a c temperature, called t timum, at which it best.



IG. 5.—Influence of temperature on bacteria ordinarily found in milk.

Most forms occur milk find their op temperature betwee and 98° F. Few b grow at all above 10 at 125° the weake soon die. An expos ten minutes at 150° t F. is fatal to nearly a teria which do not spores. Spores, a viously mentioned, a stroyed only by pro boiling, exposure to under pressure, or high degree of dry With dry heat, such obtained in an oven, higher temperature longer exposures are sary to secure the sa sults. In the labo small flasks of mil sterilized by holding in a small steam boi a temperature of 24 for fifteen minutes. fig. 5.)

If the milk is coole held at 50° F. or, bette 0°, growth is checked at once and multiplication is very slow. riter has represented the relative increase of bacteria in milk t different temperatures as follows:

Multiplication of bacteria in milk held at different temperatures.

Milk held at—	Relative number of bacteria at the end of—				
	0 hour.	6 hours.	12 hours.	24 hours.	48 hours.
8° F	1	1.7	24.2	6, 128.0	357, 499.0
0° F	1	1.2	1.5	4.1	6.2

In the foregoing table, 1 is assumed to represent the number of bacteria in the fresh milk, and the relative numbers which will be found at the end of six, twelve, twenty-four, and forty-eight hours, at the two temperatures, are shown in the succeeding columns. These figures are based on a number of actual counts and illustrate the effect of a difference of 18° on the multiplication of bacteria. If the milk had contained at the beginning 1,000 bacteria, the part held at the lower temperature would have contained at the end of twenty-four hours only 4,100 bacteria, while the other would have contained at the same stage 6,128,000.

The temperature may have a decided influence on the kind of bacteria growing in milk as well as on the numbers. There is a constant struggle for existence among the various kinds of bacteria in the milk, and those which find the conditions most favorable or succeed in so changing the milk that it is more favorable or less unfavorable to them than to other kinds will gradually crowd the others out. If a sample of milk is divided into three parts and held at three different temperatures—as, for instance, 35°, 70°, and 98°—the bacteria predominating in each of these parts at the end of two or three days will probably be quite different. Thus we see how it is that milk may undergo so many changes. Even when milk is handled in the same way day after day there may be marked differences in its appearance or flavor. Changes in the conditions so slight that they may escape our notice may produce great variation in the final results. The amount and nature of the contamination must necessarily vary more or less from day to day. Even with the same contamination the temperature of the atmosphere may change the whole course of the fermentation.

SOURCES OF BACTERIA IN MILK.

It has been assumed by many writers that milk is formed in the udder entirely free from bacteria. This has frequently been disputed and is still a matter of some doubt. However, the best authorities agree that milk is bacteria-free when formed, unless the udder is so injured or diseased that there is a direct passageway from the blood vessels to the milk ducts. It should be remembered that an injury so slight that it would escape the most careful examination might be sufficient to allow the passage of bacteria.

Even if the milk is secreted bacteria-free, it is very difficult to obtain it perfectly sterile. Bacteria work their way into the milk cistern through the opening in the teat and find there conditions under which they can grow and multiply. This growth is ordinarily confined to the lower part of the udder, and the greater number of the bacteria are washed out with the first few streams of milk. Sometimes, however, the growth may extend into the smaller milk ducts, and the last part of the milk will contain nearly as many bacteria as the first.

Inflammation of the udder or fermentation of the milk in the udder rarely occurs, because there is only a very small amount of milk held in the udder, and most of the bacteria found there have little or no effect on milk. It is also true that fresh milk, like the blood, contains some substance which has an inhibiting influence on bacteria. This influence is so slight that it is probably of little practical importance, but it may have some relation to the comparatively slow development of bacteria in the udder.

The real contamination occurs after the milk has left the udder. In spite of careful milking, dirt, particles of dust, hairs, even bits of manure from the flanks or udder of the cow, may fall into the milk. All of these things invariably carry more or less bacterial contamination. Manure usually contains large numbers of bacteria, many of them being kinds which produce very undesirable changes in milk; and the dry dust of the stable floor contains great numbers and varieties of bacteria. This dust soon settles, and an open milk pail catches a surprisingly large amount.

But the contamination does not end here. The pails or the cans may not be properly cleaned, and the corners or seams may hold small particles of dirt or sour milk. These impurities are full of bacteria, which quickly find their way into the milk. The cloth through which the milk is strained may not have been properly scalded, and the bacteria are not only not all destroyed, but have actually multiplied in the damp cloth. When the strainer is used again many of these bacteria are washed out by the milk.

If a cooler is used it may add to the contamination if it is placed so that it catches dust. Finally, the bottles in which the milk is distributed may not have been properly washed and steamed, and thus may become another source of contamination.

The contamination from each individual source may be small, but taken all together it has a serious influence on the quality of the milk. If extraordinary precautions are taken to prevent contamination, the number of bacteria in the fresh milk may be kept down to a few hundred per cubic centimeter; with careful milking it may easily e kept within a few thousand; with careless milking and handling 1e number will vary greatly with circumstances and may exceed 00,000.

The bacteria in milk from cows kept in stables may be different om the bacteria in milk from cows on pasture. Bacteria which cur rarely in milk during the winter months may become numerous the summer, and specific fermentations which are almost unknown the summer may appear in the autumn or winter.

It should not be assumed that all bacteria are harmful either to ilk or to the human system. In fact, many kinds of bacteria will ow in milk for a long time without changing its taste or appear- ce, while many of the fermentations which make milk undesirable r direct consumption are used in making butter and various kinds cheese. Very few of the bacteria cause disease or produce poison- us by-products.

FLAVORS IN MILK.

Milk may acquire abnormal flavors and odors in various ways:

(1) The cow may, through some pathological condition, produce ilk with an unusual flavor. This may occur when the cow shows o outward sign of disorder and usually lasts for a short time only.

(2) Highly flavored foods may impart their peculiar flavors to the ilk. The disagreeable results of feeding even small quantities of ild onion, turnips, and similar feeds are unfortunately too familiar o need comment. Other feeds with a less pungent taste no doubt ffect the flavor of the milk to a less degree.

(3) Milk, especially warm milk, takes up the odors and flavors of e surrounding air with great rapidity. The flavor thus acquired ay be so slight that it ordinarily passes unnoticed, or it may be so ronounced that anyone may recognize its source.

(4) The flavor of milk may be materially changed by the growth f bacteria, with the infinite variety of by-products which result om their development. If milk is sterilized and then inoculated ith some one kind of bacteria, a certain flavor, frequently very pro- ounced, will result; and under the same conditions this particular riety will always produce the same flavor. Another kind may pro- uce an equally pronounced but entirely different flavor, while some ecies may grow for a long time without causing any noticeable ange. In ordinary milk, however, the conditions are different, in at many kinds of bacteria are growing together and the milk is ually consumed before there is any marked change in the flavor.

When a number of different kinds of bacteria grow together, as ey usually do in milk, the development is not equal. One variety ds the conditions of food or temperature or acidity more suited to s peculiar habits of life and develops more rapidly than other kinds.

In a short time this rapidly growing form may so change th that, while the conditions are more favorable to its own growt become less and less adapted to the needs of the others. In the of time this form crowds out all others and an examination show large numbers of this kind, while the others originally would have entirely disappeared or would occur only occasi It is in this way that the special fermentations develop.

If milk shows a peculiar flavor when it is first drawn, it is say that the flavor is not produced by bacteria but by the cow, through something in the feed. If, on the other hand, the fre is normal and the flavor develops as the milk stands, it is usua to bacteria.

SOURING OF MILK.

Many of the lower plants find sugar a suitable food. In use of this food, the sugar is chemically changed and in its pl find many new chemical com differing widely from the from which they originated. bacteria in this process form ous kinds of acids and Among these is a large gr closely related bacteria whic the souring of milk by br up the milk sugar into lacti On account of this peculiarit are commonly called the lact bacteria (fig. 6). Typical lact bacteria do not form gas. do not have spores and therefore are destroyed at a comparativ temperature. They are extremely widely distributed, and it under exceptional conditions that milk is obtained entirely fre them. They seldom or never occur in the udder itself, but pr are introduced into the milk with the hair, bits of feces, and du fall into the milk in the barn.

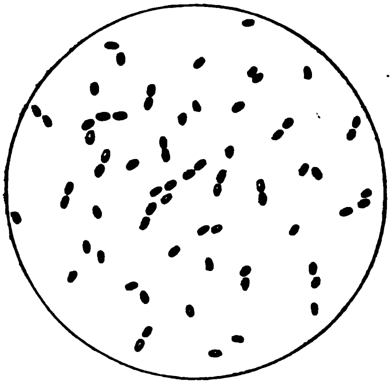


FIG. 6.—Typical lactic-acid bacteria.

Milk is an excellent medium for the growth of lactic-acid ba and under favorable temperature conditions they multiply w tonishing rapidity.

The acidity of the milk is so closely connected with the lif esses of this group of bacteria that it may be taken as a rough ure of their development. The acid, as fast as it is formed, chemically with the casein, which exists as very fine particle pended in the milk serum. When the acid reaches a certain pe the acid casein is precipitated and the milk is said to have "cur or "clabbered." This result may be hastened by heating. If or cream that is slightly sour is added to hot coffee, or is otherwise heated, it curdles.

Milk which has undergone a strictly lactic-acid fermentation has a firm curd, free from gas bubbles and with a small amount of whey on the surface. When shaken the curd breaks up into small particles which settle slowly, leaving a clear whey. The milk should have a pleasant acid taste. So far as is known, none of the products of the bacteria of this group is of a poisonous nature.

Some of the bacteria commonly classed with the lactic-acid bacteria form acids other than lactic, together with large quantities of gas. Milk curdled by bacteria of this class shows gas bubbles and has a disagreeable taste.

The lactic-acid bacteria not only are able to grow in an acid medium, but to a certain point the acid is a favorable influence. Many bacteria, however, find the acid detrimental to their development and are not able to grow long in milk in competition with lactic-acid bacteria. When the milk begins to taste sour the growth of nearly all nonacid-forming bacteria is checked. The activity of the lactic-acid bacteria themselves is checked and finally ceases entirely when the acid reaches a certain concentration, which varies with different varieties. Consequently sour milk usually contains a nearly pure culture of one or at most two or three closely related varieties of bacteria.

While the lactic-acid bacteria are considered very beneficial in butter and cheese making, they are undesirable bacteria from the standpoint of the milk dealer or consumer. It is almost out of the question absolutely to prevent their presence in milk, but the initial number may be much reduced by observing a few simple rules of cleanliness in handling the milk. Every precaution which reduces the amount of dirt in milk reduces the number of bacteria correspondingly. The important factors here are freedom from dust at time of milking, brushing the cows, wiping the udders, and small-mouthed milk pails. It is also of great importance to cool the milk as soon as possible after milking to below the temperature at which lactic-acid bacteria grow rapidly. This temperature is controlled by practical conditions, such as the temperature of the water available for cooling, but it should not be higher than 50° F.

SWEET CURDLING AND DIGESTION.

It sometimes happens that milk curdles without showing the usual acid taste. This is followed by the separation of a straw-colored whey, which slowly increases until the curd has nearly all disappeared. This condition is the result of a series of complicated changes brought about by bacteria.

When milk is taken into the stomach, especially the stomach young animals whose diet is largely or wholly milk, a certain c stituent of the digestive juice precipitates the casein, forming a curd. This curd resembles the acid curd in appearance, but dif from it chemically and has no sour taste. The part of the diges juice which produces this change is the rennet, with which we familiar in cheese making and in the junket tablets of the kitc It is what is technically known as an enzyme, and while it has s of the properties which we ordinarily attribute to living beings action is purely chemical.

In this precipitated condition the casein is not in a form to be by the animal. It must be so changed that it will go into a solu and pass through the membranes lining the digestive tract. change is brought about by another enzyme, pepsin. Pepsin cha the curd rapidly and completely into compounds soluble in water.

A process similar to these digestive processes in the stomach t place in milk when it is subjected to the action of certain kin bacteria. The bacteria have no stomachs, but some of them have ability to secrete enzymes somewhat like the rennet and the pepsi animals. Thus the milk can or bottle becomes in a certain sense communistic stomach of myriads of bacteria. From each cell is g out a trace of rennet and the digesting enzyme. These enzymes h the peculiar property of acting continuously without reduction of t power. Thus it happens that the milk is curdled in a few hours the casein is slowly converted into products capable of passing thro the delicate membrane surrounding the bacteria. The food thus duced is obviously far in excess of the needs of the bacteria.

A large group of bacteria, more or less closely related, prod changes of this nature. Some of them form by-products with agreeable odors and tastes and some form gases. They are fo normally in the soil, in water, in the filth of the stable, or the that floats in the air. They are invariably found in milk in grea or less numbers. They are ordinarily checked by the activities the lactic-acid bacteria and become predominant only under spe conditions. When, through careless handling, any exceptional nu ber of bacteria of this class are introduced into the milk, they bring about rennet curdling and digestion before they are suppres by the acid produced by the lactic-acid bacteria.

Again, in hot weather the temperature of the milk may be so h that it is more favorable to the digesting bacteria than to the lac acid bacteria and the former gain the ascendency.

BITTER MILK.

The distinct bitter taste which sometimes appears in milk may be
used by (1) certain weeds that the cow has eaten, (2) an abnormal
ndition of the udder, (3) an advanced period of lactation, or (4) the
tion of certain bacteria. The first three causes of bitter milk need
t be discussed in this paper. It is probable that the bacteria caus-
g bitterness are not at all uncommon and that they could be found
many lots of milk showing no bitterness. Some of these bacteria
rm acid and sour the milk; the more common forms, however, form
tle acid, and are checked by the growth of the lactic-acid bacteria.
arly all of them form spores, and thus survive heating, which
stroys the lactic-acid bacteria. For this reason bitterness has been
st frequently observed in pasteurized and imperfectly sterilized
lk. The few remaining spores germinate, and as they are unhin-
red by the presence of lactic-acid bacteria they soon reach unusual
mbers and the bitter flavor appears.

The bacteria causing bitterness in unheated milk are more frequently
ose of the acid-forming classes, which are better able to compete
th the lactic-acid bacteria. The acid formed by this group is usually
tyric and not lactic. Some writers have stated that the bitterness
aused directly by the butyric acid. Nearly all of the bacteria known
produce bitterness bring about an active digestion of the casein and
umen, and it is probable that the bitter principle is formed in this
composition. In most cases, however, the bitterness becomes evi-
nt before there is any visible sign of change in the milk.

Bitter milk may occur as an epidemic, persisting day after day and
using great trouble. This may be due to some constant localized
urce of infection which adds each day unusual numbers of bacteria
the milk. In some cases it has been found that the udder of a cow
as infected. This should be determined by carefully cleaning the
dders of all the cows and milking from each quarter of the udder of
ch cow into fruit jars or bottles which have been previously cleaned
ith boiling water.

In case one of these samples shows a well-developed bitterness while
hers remain normal, it may be assumed that the source of infection
the udder of the cow giving this milk. In that case there should be
jected into the udder after each milking a solution of 1 part hypo-
lphite of soda in 100 parts of water.

It is probable in many cases that the source of infection is not local-
ed. If through some combination of circumstances the lactic-acid
cteria are suppressed, other kinds become predominant. The uten-
ls, the milk room, and the stable gradually become inoculated with
ese bacteria or their spores and each new lot of milk is thoroughly
oculated. The bitter-milk bacteria may be one of the new forms.

In this event it may be necessary, after thoroughly cleaning and steaming everything coming in contact with the milk, to introduce some good sour milk from a neighboring dairy. In this way the normal fermentation may be restored and the objectionable bacteria suppressed.

ROPY OR STRINGY MILK.

In this most troublesome fermentation the milk becomes what is commonly described as ropy or stringy. The milk is slimy and viscid. As this condition increases the milk may be drawn out into threads.

This fermentation should not be confused with garget, which appears in the fresh milk and is due to an inflammation of the udder. Ropy or stringy milk develops after the milk is drawn and is caused by the growth of certain kinds of bacteria. Although a number of kinds of bacteria causing this trouble have been studied as distinct varieties, it is probable that they are nearly all closely related. They do not form spores and are therefore destroyed by a comparatively low heat.

If a sample of ropy milk is examined under a microscope it is found to be filled with these small bacteria, each one surrounded by a capsule of a sticky, gummy substance. This gum or slime holds the bacteria together. When a thread is drawn out it is really a chain of bacteria held together by their sticky capsules.

Ropy milk is, so far as known, in no way detrimental to health. The famous Edam cheeses are nearly all made from milk which has undergone this fermentation. The peasants of Norway consider ropy milk a desirable beverage and bring about this fermentation by adding to fresh milk the leaves of certain plants on which the bacteria causing ropy milk are abundant. Most people, however, object seriously to milk with any tendency to form threads. This trouble frequently affects the milk of a dairy day after day and is removed only by the most drastic measures.

Outbreaks of this nature frequently occur in the cold months because the bacteria of this group thrive better at low temperatures than the lactic-acid bacteria which hold them in check under normal conditions. In one case it was found that these bacteria were abundant in the dust of the stable. The trouble was removed by a thorough cleaning and whitewashing. In another serious and persistent outbreak it was found that the milk as it came from the dairy contained few or no ropy milk bacteria, but that they were abundant in [illegible] water tank in which the milk was held over night. The small amount of water occasionally splashed into the cans added sufficient bacteria to make the milk ropy in a comparatively short time. The utensils and floor had become so thoroughly impregnated with this organism that milk exposed in the room or strained through the wire strainer became ropy without contamination with the water. The trouble removed by thoroughly scalding all the utensils, disinfecting the floor with a 5 per cent sulphuric acid solution, and destroying the organisms in the ice water by adding potassium bichromate. This was used in the proportion of 1 part in 1,000 or, roughly, 1 ounce to 1 cubic foot of water.

The source of the trouble can sometimes be easily located by taking small samples of the milk in clean glass jars at different stages in the handling. These should be covered, set away in a cool place to retard the souring, and examined after twenty-four to thirty-six hours for indications of ropiness.

In dairies getting milk from a number of farms the source of the difficulty may be located on some particular farm and proper methods taken to remove the source of contamination.

Any precaution is almost sure to be ineffectual if all utensils coming in contact with the milk are not thoroughly scalded, or, better still, steamed.

MISCELLANEOUS FERMENTATIONS.

In addition to the various fermentations previously described, milk may undergo many other changes as a result of the action of bacteria or other micro-organisms. The color may be changed. The appearance of color in milk is due to the growth of bacteria which produce a pigment soluble in water. All the colors of the rainbow, from bright red to violet, are formed by bacteria. Blue milk, which is the most common of the color fermentations, is probably due to contaminations from water, in which the blue and violet forming bacteria are known to occur frequently. It is only under unusual circumstances that these bacteria occur in milk in sufficient numbers to give any trouble.

Milk sometimes undergoes an alcoholic fermentation, and in some countries this is brought about by proper inoculation and control of temperature to produce a beverage. The alcoholic fermentation is usually caused by a yeast which has the ability to break up milk sugar into alcohol and large quantities of carbon dioxid gas. The ordinary yeast, such as is used in bread making, produces similar changes in cane sugar, but does not affect milk sugar. In the alcoholic drinks made from milk the alcoholic fermentation is usually combined with an acid fermentation. Koumiss, a drink made originally in the Caucasus from mare's milk, is a combination of an alcoholic and a lactic-acid fermentation. This drink is believed to be beneficial in some diseases of the stomach and is frequently made from cow's milk. When made in this way with ordinary yeast it is necessary to add cane sugar.

DISEASE-PRODUCING BACTERIA IN MILK.

It is now generally recognized that many of the diseases whic be communicated from one person to another are caused by s bacteria. The organisms causing some of these diseases have n been discovered, but the causal bacteria of many have been is and studied in detail. Some of these diseases occur usually o human beings, others occur usually in animals and are only oc ally transmitted to men, while others may occur with equal freq in both man and animals.

It is well known that certain diseases are sometimes dissem through milk. By this means an epidemic may appear sudde last for a comparatively short time, or the infection may be co for a long period and the development of the disease be so sl obscure that the source is unknown.

Tuberculosis is an example of the latter class. So much in to this disease is still unknown, so many widely separated vi held, even by those most familiar with the subject, that it is sible to make positive statements. However, tuberculosis h studied in such detail that many facts have been well establis many theories advanced are so probable that they can not b garded until they are disproved.

The question of the identity of tuberculosis of man with animals has been raised, and while it is not yet accepted as a all investigators, a large majority of the people whose opi weight believe that the two diseases are identical. Assuming t are, much difference of opinion exists as to the possibility mission from cows to man through milk. It is well known th animals, including calves and pigs, may be infected by drinki from tuberculous cows, and the possibility that man, and e children, may become infected in this way is so great that gard it on the ground that it is still unproved is carelessness a ing criminal negligence. The tendency among those who are the question most carefully is to consider milk as a serious s danger.

A number of epidemics of diphtheria and scarlet fever ha traced to the milk supply. In diseases of this nature the mil fected by someone suffering from an attack of the disease, or someone who has been in contact with the patient. Obviousl suffering from a contagious disease, or one who is caring for a person, should be allowed to go near the stables or milk room o milk utensils. The only really safe way is to enforce strict qu against farms where contagious diseases are known to exist.

Typhoid fever, while not classed as a contagious disease, municated from one person to another. The ordinary cha mmunication is generally considered to be the drinking water, ich may be contaminated by sewage, but occasionally it is dissemi-ed through the food. Milk may become infected with this disease various ways. Contaminated well or spring water may find its way o the milk through milk pails, cans, or bottles which were not thor-ghly scalded after rinsing in cold water; the cans or bottles of milk y be left to cool in contaminated water and become inoculated by accidental addition of even a few drops of water; the cows may le in water or mud containing the typhoid bacillus and the small ps of muddy water which dry on the animal's flank may carry organism to the milk; or flies may go directly from the waste m the sick room to the milk or milk utensils. It must be remem-red that milk is an excellent medium for the growth of disease cteria as well as the more harmless forms; and if temperature nditions permit, the comparatively few bacteria carried in a few ops of water, a speck of mud, or the legs of a fly begin to multiply d soon reach dangerous numbers.

In this connection must be considered the summer intestinal dis-ses of children. While the specific bacteria causing these troubles ve not been recognized in all cases, it is generally accepted that y are carried by the milk and that this is the important factor in ir control. It has been proved by careful observation and statis-s that the death rate among babies in the crowded cities can be terially lessened by supplying them with good milk. It is believed t these troubles are caused not by single species, but by a group of gesting bacteria, which produce poisons in the milk, together with er decomposition products. This class of bacteria is typical of l milk, milk that has been handled in an insanitary manner, or not pt at a low temperature.

THE HANDLING AND CARE OF MILK.

Preventing changes in milk is a question of preventing the intro-ction of bacteria into milk and of checking their growth or destroy-g them when they are present. The production of milk reasonably e from bacteria is a simple question of cleanliness.

How far a milk producer can go in this direction with profit is a estion that each one must decide for himself. The model dairies ich are used as examples of what dairymen should do are fre-ently maintained in such an expensive manner that the farmer or iryman doing a small business or producing milk in connection with er lines of farming can not expect to live up to their standards thout increasing the cost of his milk.

However, there are many simple rules and methods for handling lk, requiring little extra labor and no added expense, which will materially increase the healthfulness and keeping quality of the product. Any precaution that reduces the dust in the stable at milking time reduces the initial number of bacteria in the milk. The cows should not be fed before milking. Cobwebs and other dirt can be easily removed from the ceiling. The stable floor should be so arranged that the dirt on the flanks and udders of the cows will be reduced to a minimum. The daily use of a brush will add greatly to the efficiency of these precautions. Care should be taken that the cows do not have to wade through filth in the barnyard.

Even with the greatest precaution some bacteria get into the milk, and further precautions must be taken to prevent their undue multiplication. The practical way to accomplish this is by control of the temperature of the milk. Advantage is taken of the natural laws governing the limits and rapidity of growth of bacteria at different temperatures. The milk should be cooled at once to a temperature as near the freezing point as circumstances will permit. The usual limit is 50° F., but 40° F. is much more desirable.

The quickest and most economical method is to run the milk in a thin layer over the surface of a receptacle containing cold water. Many varieties of coolers for this purpose are on the market. Some are so arranged that a stream of water passes through them, while in others the milk flows over a conical tank containing cold water. A cooler should be located in a clean, well-ventilated room, or the benefits of cooling will be overcome by contamination from dust and the absorption of bad odors.

On farms where water is supplied by a windmill it is very easy to arrange the water trough so that the water flows from the pump through a trough or tank in which the cans of milk may be set to cool. This is a slow method, but much better than nothing.

It is not sufficient merely to cool the fresh milk. To insure good results it must be kept cold until used. The housekeeper who leaves her bottles of milk in the sun or standing in a warm kitchen should not blame the milkman for sour milk.

Various attempts have been made to preserve milk by holding it above instead of below the temperature favorable to the growth of bacteria. Devices for this purpose are called thermophores. While the most favorable temperature for many bacteria is at or near 98° F., few grow well at temperatures a few degrees above this point, and at 110° to 120° ordinary forms will not grow at all.

Milk held in thermophores usually will not curdle or change appreciably for several days, but it has been shown that unusual kinds of bacteria are able to develop at these high temperatures and that the milk which has every appearance of being good may contain large numbers of bacteria whose action is unknown. Devices for keeping infants' milk warm through the night should never be used.

emicals having an injurious effect on bacteria are sometimes used
tard the growth of bacteria in milk and thus prolong the time
in which it may be sold. This practice is so universally con-
ned by public opinion that it need not be discussed here.

eat is frequently applied to milk to destroy a part or all of the
eria. Complete destruction of all bacteria in any substance is
ilization; pasteurization is a term used to designate a process by
ch milk or other fluids are heated to destroy part, but not all, of
bacteria. Pasteurization may be "continuous" or "intermit-
;" in the first method the milk flows in a continuous stream
ugh the pasteurizer, where it is heated to the required tempera-
by steam or hot water; in the second method the milk is heated
similar way, but is held at the pasteurizing temperature for some
.

he temperature for pasteurizing varies greatly. As a general rule,
sure good results, the temperature must be increased as length of
sure is decreased. When the milk is held for twenty to thirty
utes the temperature may vary from 140° to 160° F. The former
perature is the lowest point at which the bacillus of tuberculosis is
royed. To make the destruction of this bacillus certain the milk
t be held at 140° for at least twenty-five minutes and be constantly
ed. In the continuous machines, where the milk is maintained at
pasteurizing temperature usually for only twenty-five or thirty
nds, the temperatures used range from 160° F. to 185° F. The
lts at 160° F. are uncertain, and any temperature below this point
ittle or no beneficial effect. Milk may be efficiently pasteurized
e household by setting the bottle of milk in a vessel containing
r, and heating the water until the milk reaches a temperature of
t 150°. It may then be removed from the stove and allowed to
d for twenty to twenty-five minutes. The temperature of the
r will be above that of the milk, and while it slowly cools the
will be thoroughly heated. It should then be chilled at once and
cold until used.

steurization should not be confused with sterilization. Even
n the former is efficiently done, the vegetative or growing bacteria
are killed. Spores may resist boiling for several hours, and it is
ual to find milk entirely free from spores. Under proper tem-
ture conditions these soon germinate and the milk may in a short
be worse than before pasteurization. In other words, pasteurized
must be kept from contamination and warmth as well as the
steurized product.

ilk may be sterilized by repeated boilings. This is usually accom-
ed by steaming on three or four successive days. After each
ing it should be held at room temperature for twenty-four hours
llow the spores to germinate and reach the vegetative stage.

Sterilization may be effected in one operation by exposure to a temperature above the boiling point. To effect this exposure it is necessary to hold the milk in a closed chamber with steam under pressure.

Milk can also be sterilized by chemical means. The so-called "Buddeized" milk is sterilized by adding a small amount of hydrogen peroxid, which acts energetically on bacteria and is itself slowly decomposed into two harmless substances, oxygen and water. Milk treated in this way is said to be not entirely free from an objectionable taste and the sterilization is not always certain.

While bacteria are in no way essential to milk, they may be considered as normally present in milk, cream, ice cream, butter, and cheese. They may even occur in milk or its products in very large numbers without making it an unsafe food or in any way decreasing its food value.

Bacteria known to produce disease are seldom isolated from or counted in milk, and bacteriological counts should be taken merely as an indication of the way in which milk has been collected or the temperature at which it has been held. High numbers usually indicate insanitary conditions, careless handling, or old milk. However, milk may be collected under very poor conditions and the bacterial count held down by a liberal use of ice. On the other hand, milk collected in the most sanitary manner may in a few hours contain a large number of bacteria if it is held at a high temperature. Low counts may be due not to clean stables and low temperatures, but to the use of antiseptics.

Every effort should be made by legitimate means to secure milk with a small number of bacteria, but milk or foods made from milk should not be indiscriminately condemned because they sometimes contain bacteria in numbers which are startling to those not familiar with the nature of these indispensable plants.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 349.

HE DAIRY INDUSTRY IN THE SOUTH.

BY

B. H. RAWL, DUNCAN STUART, AND
GEORGE M. WHITAKER.
Dairy Division, Bureau of Animal Industry.

WASHINGTON:
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1909.

UNIVERSITY

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., December 9, 1908.

Sir: I respectfully transmit herewith a series of papers relating to The Dairy Industry in the South," prepared by Messrs. B. H. Rawl, uncan Stuart, and George M. Whitaker, of the Dairy Division of is Bureau.

In 1906 the Dairy Division began systematic field work in the uthern States for the development of the dairy industry in that sec- n. This work has been carried on in cooperation with State periment stations, agricultural colleges, and departments of agri- ture, and has steadily increased until at present a representative the Dairy Division is working in each of nine Southern States. e work has consisted largely of personal effort among the dairy mers with a view to teaching them better methods, and has pro- ced good results.

Fundamental to any question of production is the question of rkets, and in order that the field workers might properly advise irymen regarding the marketing of their products it was found cessary to make a systematic study of this subject. Consequently, ring the fall of 1906 and the following winter, a representative of e division made a close inspection of the markets of 50 cities, the sults of which are shown in the first paper. Prices were generally wer when this inspection was made than they were in 1907–8, but her conditions have not materially changed.

In the prosecution of this work it was realized that a decided provement in the quality of the milk supply of the cities through- t the South was needed. Insanitary methods of producing and ndling milk were a great menace to public health. In 1907 an spector was assigned to investigate the situation more fully and give sistance in applying methods that would bring about improvement. e second paper discusses various phases of this question.

The report on markets shows that only a small part of the dairy oducts consumed in the South are produced in that section. A pre- minary survey of the whole field was made in 1905 by Mr. Rawl, fol-

lowing which Congress made a special appropriation to prosecu
work on a more extended scale. This support by Congress ha
been continued in the general appropriation for the Bureau of
Industry. The third paper describes the conditions which seen
responsible for this small production of dairy products in the So
States, and tells why dairying has remained an undeveloped in
in that section of the country.

These papers form a part of the Twenty-fourth Annual Report
Bureau, but as they deal with a subject of great interest and i
tance to a large section of the country I respectfully recommen
they be made available for a wider distribution by reissuing
as a Farmers' Bulletin.

Respectfully,

A. D. MELVIN,
Chief of Bur

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE DAIRY INDUSTRY IN THE SOUTH.

SOUTHERN MARKETS FOR DAIRY PRODUCTS.

By DUNCAN STUART,

Assistant in Dairying, Dairy Division, Bureau of Animal Industry.

During several months in 1906–7, 50 of the larger cities in 12 States
he South were visited by the writer in order to obtain data [illegible]
to the dairy markets of that part of the [illegible]
e collected as to the amounts of butter, [illegible]
k, and cream handled in these cities, and an [illegible]
ermine what proportion of these amounts [illegible]
thern and Western States. Table 6 [illegible]
butter and cheese consumed in this [illegible]
dairymen. In looking over these [illegible]
d also that the prices obtained at [illegible]
n at the present time (1908 [illegible]
ed by home production of these [illegible]

During the past year, [illegible]
blished, particularly in K[illegible]
reported 7 creameries in K[illegible]
3; while in the spring of [illegible]
se facts indicate that [illegible]
oming of more [illegible]

[illegible]

[illegible]

The creamery [illegible]
meet the [illegible]
uthern States. [illegible]
y made [illegible]
, at Fort W[illegible]
ate, and [illegible]
ma. Chattanooga [illegible]
thern creameries [illegible]

price equal to that of the best northern and western produ amounts of print butter are shipped in by the butter con Illinois, Wisconsin, and Kansas; tub butter also is used e: the larger retail stores using the "cut-to-weight" butt Some butter is made in cities by the large milk plants, w their surplus milk and cream into butter. This fresh but up in attractive prints and finds a ready sale among customers.

Butter is shipped in refrigerator cars to the larger tra and from these points is reshipped to the smaller towns, usu out refrigeration. The great disadvantage of the butter b the South is the lack of proper equipment for handling modity. The small retail stores often do not have prop facilities, consequently the butter is soft and in many cases h rancid before it is sold to the consumer.

It will be noted in Table 4 that about 23,435,000 pounds ery butter annually is brought in from Northern and Weste

The census of 1900 reported the production of creamery butter in the South as follows:

TABLE 1.—*Production of creamery and farm butter in Southern State 1900.*

State.	Butter mad on farms.
	Pounds.
Alabama	19,121,964
Arkansas	21,585,258
Florida	1,386,445
Georgia	15,111,494
Kentucky	30,446,381
Louisiana	4,918,229
Mississippi	18,881,236
North Carolina	16,913,802
South Carolina	8,150,437
Tennessee	29,091,696
Texas	47,991,492
Virginia	19,905,830
West Virginia	16,913,129
Total	250,417,393

From the above figures it will be noted that of the total of butter produced in the South in 1899, only a very small p made in creameries. It may be stated also that the relative tion has not materially changed since.

Dairy and Country Butter.

The quality of the dairy butter varies greatly. Some of t ter dairies are making a product almost, if not quite, equal best creamery butter. It is delivered to the consumers in rints neatly wrapped in parchment paper and bearing the mono- ram or name of the dairy. Though this grade of butter is compar- ively limited in quantity, it is now being supplied to the following ties by the near-by dairymen: Shreveport, La.; Raleigh, N. C.; olumbia, S. C.; Macon, Augusta, and Atlanta, Ga.; Tallahassee, la.; Montgomery and Birmingham, Ala.; Dallas, Austin, and San ntonio, Tex.

A large amount of dairy butter is shipped to the Carolinas and to eorgia from Tennessee in 5-pound and 10-pound tin pails. Some iry butter made in Georgia has been shipped to market in South arolina and sold there as Tennessee butter.

Of quite a different grade is the butter that is handled by the untry merchant. This butter is brought to him in various shapes— boxes, round prints, rolls, etc.—and in various shades of color. He tails what he can of it, and the balance he ships in tin cans or in rrels to the commission men in the large cities. By the time it aches them it is apt to be very rancid, as a result of not having been operly washed when it was churned. One needs only to visit these mmission merchants to see a product resembling axle grease more an butter. This quality of butter is bought as low as 7 cents a und. The butter dealers of Austin, San Antonio, and Fort Worth, x., together ship annually about 300,000 pounds of this grade of tter to the renovating factories.

The butter produced in the South, even if it were all of the best ality, is of insufficient quantity to meet the demand; yet a large rt of that which is produced has to be shipped to the renovating ctories, as noted above, and treated by them before it is actually nsumed. We see, therefore, that an advance must be made in the ethods of manufacture, as well as in the amount turned out, before uthern butter can meet the demands of consumers in that section.

Renovated Butter.

Quite a large amount of the butter consumed in the South is novated or "process" butter. Reports gathered from 50 cities ow an annual consumption of about 7,163,000 pounds, while the duction of the renovating factories in that section of the country only about 33,300 pounds.

Renovated butter is retailed at an average price of 26 cents a pound. ch of it selling for 30 cents, and during the past winter (1907–8) as sold as high as 35 cents a pound. Using the average price of cents a pound, the annual value of the sales of this grade of butter ounts to about $1,862,300 for 39 cities. Inasmuch as renovated tter can be bought at a lower price than creamery butter there is a great temptation to sell it as creamery butter, and some deale undoubtedly doing this.

OLEOMARGARIN.

The Fifty-sixth Congress, second session, in Senate Report under date of January 26, 1901, published data furnished l Treasury Department from its figures for the year 1899 showi amount of oleomargarin shipped into the various States. A time 11.5 per cent of the total amount consumed was used South.

Since the act of May 9, 1902, which imposed a tax of 10 c pound on the colored product and one-fourth of a cent on t colored, the consumption of oleomargarin has decreased. Ho the consumption of this article is still great in some of the cities, especially in the winter season. Large amounts are h in Norfolk, Richmond, Charlottesville, and Lynchburg, Va.; C nooga, Nashville, and Memphis, Tenn.; and Louisville, Lexi Newport, and Covington, Ky. One of these cities uses as m 700,000 pounds annually.

The colored product retails as high as 32 cents a pound, wh uncolored retails at an average of from 15 to 20 cents. Of the a consumed in the South less than 8 per cent is manufactured i section.

The scarcity of creamery butter in the winter season, and t evenness of color and the tendency to rancidity which chara the country butter, account for the large consumption of the grades of oleomargarin.

The following table shows the amounts of oleomargarin u States in 1899 (according to the census of 1900) and the appro amounts used in the fiscal year 1905–6:

TABLE 2.—*Quantity of oleomargarin shipped into Southern States in 18 in fiscal year 1905–6.*

State.	1899.	Fi
	Pounds.	*P*
Alabama	226,053	
Arkansas	380,389	
Florida	590,225	
Georgia	495,004	
Kentucky	1,490,577	1
Louisiana	1,043,502	
Mississippi	104,622	
North Carolina	110,244	
South Carolina	258,159	
Tennessee	714,640	
Texas	1,518,264	
Virginia	1,159,400	1.
West Virginia	1,206,865	1.
[illegible]	9,297,944	6,

CHEESE.

Practically no whole-milk cheese, or cheese of the Cheddar type, is manufactured in the South. A few small factories are reported in South Carolina (two at Easley), Virginia, and West Virginia, but the output of these factories is very insignificant in comparison with the large amount consumed. In the 50 cities visited in 13 States the cheese handled amounted to approximately 42,000,000 pounds annually, while the production in the States mentioned, as indicated by the census figures, was probably less than 2 per cent of this total. The per capita consumption of cheese in the South is quite considerable, as large quantities are used by the laboring classes, who depend largely on crackers and cheese for their midday lunch.

Large amounts of imported and American-made cheese of foreign types are consumed in many of the cities. Large quantities of Roquefort, Camembert, Swiss, Brick, Gorgonzola, Parmesan, Limburg, and Roman cheese are used. Roman cheese is especially popular in New Orleans, while cheese imported from Sicily is used to a large extent in Tampa, Fla. The so-called cream cheese, made by putting clabbered milk into molds to drain, is used in great quantities as a breakfast dish in New Orleans. Texas cities handle large amounts of Brick cheese, but they also consume much of the imported varieties, especially during the cool weather.

The "daisy" type of Cheddar cheese is popular. Being a small cheese—20 to 23 pounds—it is easily handled during the hot season, and in addition is readily cut by the automatic cheese-cutting machines. "Flats" and "twins" are used to some extent in cool weather in the extreme Southern States, and to a larger degree in the Carolinas, Kentucky, and Tennessee.

Whole-milk cheese usually retails at 20 to 25 cents a pound, but in a few cities it is retailed as low as 17 cents a pound. Skim-milk cheese is being sold to some extent and is not always correctly branded. New York State cheese and Wisconsin cheese are the principal ones on the southern market.

The census of 1900 gives the following figures on the cheese production of the Southern States:

TABLE 3.—*Quantity of cheese produced in Southern States, census of 1900.*

State.	Cheese made on farms.	Cheese made in factories.
	Pounds.	*Pounds.*
Alabama	36,374	[illegible]
Arkansas	18,385	[illegible]
Florida	3,751	
Georgia	2,236	
Kentucky	45,739	[illegible]
Louisiana	135,104	
Mississippi	28,272	
North Carolina	28,883	
South Carolina	1,081	
Tennessee	26,622	[illegible]
Texas	136,133	[illegible]
Virginia	31,097	[illegible]
West Virginia	74,243	[illegible]
Total	568,540	[illegible]

From the above figures it will be seen that the cheese production of the South is wholly inadequate to the supply needed for consumption. The estimated amounts consumed in the larger cities of the above States, as shown in Table 4, totaled 41,582,545 pounds.

ICE CREAM.

There is a heavy ice cream consumption in southern cities. Much of the product, however, is of low grade, being made from whole milk and from bulk condensed milk. The price varies from 70 cents to $3 a gallon, the latter price being paid for a fancy grade of cream put up in special forms. The average retail price is about $1.50 a gallon.

The following are some of the cities manufacturing large amounts of ice cream: Memphis, Chattanooga, and Nashville, Tenn.; Little Rock, Ark.; Fort Worth, San Antonio, and Dallas, Tex.; Louisville, Ky.; Jackson, Miss.; Birmingham, Ala.; and Macon and Atlanta, Ga. Memphis ships the largest amount, one of its manufacturers making as high as 3,000 gallons in one day in the summer season. Ice cream manufactured in Tennessee and Georgia is shipped to points as far south as Florida.

CREAM.

In the South the consumption of cream is small. This is due to the scarcity of fresh cream rather than to a lack of demand for this dairy product. The cream sold is also quite variable in quality, some of it being only equal to a rich milk. Much unsweetened condensed milk is used in the place of cream. The fresh cream in some cities is supplied by near-by dairymen, while others get it from long distances. The larger cities of Georgia, with the exception of Savannah, are fairly well supplied with cream. Newport and Covington, Ky., get a part of their supply from Cincinnati dealers, while Louisville gets cream by rail from Illinois and Indiana. The North Carolina cities depend largely on local product; however, a small amount is shipped in from Virginia. Tennessee cities, with the exception of Memphis, are well supplied with local product. Texas cities, excepting Fort Worth, are also supplied from within the State.

Mobile, Ala., gets a part of its supply from Tennessee; all the larger cities of Florida, with the exception of Tallahassee, get a large part of their cream from points in Georgia and Tennessee; a portion of the supply for New Orleans comes from Tennessee and Illinois; Jackson, Miss., gets a small supply from Tennessee; Memphis gets a part of its supply from Mississippi and Arkansas; and Norfolk, Portsmouth, and Richmond, Va., receive fresh cream from New York City; Wilmington, N. C., Jacksonville and St. Augustine, Fla., and Galveston, Tex., depend largely on unsweetened condensed milk.

CONDENSED MILK.

Condensed milk is consumed in large quantities in southern cities and to some extent on the farms. It is put up in small cans selling for 5 and 10 cents each, but is also sold in larger sizes. The smaller sizes are very convenient for family use during the hot season. In many sections the supply of fresh milk is unsuitable for infant feeding and the physician invariably recommends condensed milk.

Fresh cream being scarce, condensed milk is used as a substitute. This is used as cream and is also manufactured into ice cream. Unsweetened condensed milk is received in 10-gallon cans at Jacksonville from New York City. Memphis gets bulk condensed milk from Arkansas. St. Augustine and Galveston also use large amounts of the unsweetened product.

The following tables give data regarding the dairy markets of 50 cities, in 13 States of the South, discussed in the preceding pa

TABLE 4.—*Quantity of dairy products handled in 50 southern cities, fiscal 1905–6.*

City.	Approximate quantity handled of—					Milk sold dai	
	Creamery butter.	Renovated butter.	Oleomargarin.[a]	Cheese.	Condensed milk.	Quantity.	Am bott
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Gallons.*	*Per*
Arkansas:							
Fort Smith	126,000	15,000	26,100	572,000	291,360	200	
Little Rock	500,000	100,000	51,000	800,000	499,200	3,300	
Alabama:							
Birmingham	291,205	278,000	136,000	1,767,520	1,453,680	1,735	
Mobile	882,400	118,000	49,300	916,000	1,227,600	1,100	
Montgomery	153,708	124,540	76,000	1,203,000	425,040	600	
Florida:							
Jacksonville	1,500,000	200,000	150,000	1,675,650	2,803,200	1,250	
Pensacola	449,340	28,541	17,800	297,120	610,800	450	
St. Augustine	....	(b)	2,000	....	....	400	
Tallahassee	9,000	....	....	41,760	27,360	150	
Tampa	742,070	91,600	18,550	400,830	2,683,680	1,500	
Georgia:							
Atlanta	630,000	20,000	61,000	2,117,500	1,126,320	5,000	
Augusta	380,100	(?)	8,440	1,289,500	....	1,200	
Macon	97,740	98,000	12,900	1,395,950	362,592	800	
Savannah	96,900	229,263	52,730	946,307	1,536,000	....	
Valdosta	102,750	34,000	600	185,000	122,208	200	
Kentucky:							
Covington	190,000	60,000	92,900	250,000	....	2,500	
Lexington	50,000	....	162,440	270,000	48,000	2,500	
Louisville	2,000,000	500,000	699,000	2,000,000	888,000	10,000	
Newport	150,000	50,000	69,000	150,000	....	1,750	
Louisiana:							
Baton Rouge	43,500	26,300	19,200	98,000	416,640	....	
New Orleans	4,700,000	800,000	187,463	2,069,976	12,480,000	16,000	
Shreveport	60,700	28,000	37,840	612,000	708,000	1,100	
Mississippi:							
Jackson	58,000	24,000	6,900	192,000	157,440	510	
Meridian	15,000	23,150	6,300	627,530	192,000	300	
Natchez	82,588	14,226	3,900	255,245	601,200	375	
Vicksburg	156,884	122,763	8,600	389,560	614,400	580	
North Carolina:							
Asheville	20,000	....	14,400	120,000	40,320	800	
Charlotte	14,600	....	1,350	543,000	(?)	675	
Greensboro	18,390	....	10,700	267,600	(?)	....	
Raleigh	26,676	2,000	19,750	203,750	(?)	250	
Wilmington	421,700	59,000	8,400	547,000	(?)	....	
South Carolina:							
Charleston	900,000	600,000	25,214	1,063,415	1,341,600	....	
Columbia	218,540	50,000	27,300	253,680	357,096	400	
Tennessee:							
Chattanooga	425,040	88,380	74,000	773,742	1,992,000	2,200	
Knoxville	50,000	5,000	46,700	400,000	105,605	2,000	
Memphis	1,314,420	416,100	107,300	4,000,000	1,805,760	8,750	
Nashville	248,100	....	98,000	1,146,200	168,000	....	
Texas:							
Austin	1,000	....	25,000	530,000	144,000	....	
Dallas	350,000	10,000	79,490	750,000	768,480	2,000	
Fort Worth	531,250	186,730	53,500	650,000	566,400	1,600	
Houston	908,460	515,608	59,700	1,037,540	2,231,136	....	
Galveston	878,000	164,500	50,000	791,300	960,000	1,120	
San Antonio	116,660	....	54,000	682,870	703,200	4,000	
Waco	27,500	....	16,000	450,000	315,216	....	
West Virginia:							
Charleston	286,720	125,000	25,214	430,000	480,000	600	
Virginia:							
Charlottesville	20,000	5,000	20,050	75,000	33,600	....	
Lynchburg	40,000	....	87,220	245,000	72,960	800	
Norfolk	2,250,000	1,500,000	113,414	4,000,000	(?)	2,000	
Portsmouth	150,000	150,000	12,700	100,000	(?)	600	
Richmond	750,000	300,000	376,118	2,000,000	1,200,000	5,000	
Total	23,434,941	7,162,701	3,361,483	41,582,545	42,560,688	....	

[a] Consumed.

[b] St. Augustine included in Jacksonville report.

TABLE 5.—*Wholesale and retail prices of dairy products handled in 50 southern cities, fiscal year 1905–6.*

City.	Milk.			Cream.			Butter.		
	Paid to producer, per gallon.	Retail, per gallon.	Retail, per quart.	Paid to producer, per gallon.	Retail, per quart.	Fat.	Creamery, per pound.	Dairy or country, per pound.	Renovated, per pound.
Arkansas:	*Cents.*	*Cents.*	*Cents.*		*Cents.*	*Per ct.*	*Cents*	*Cents.*	*Cents.*
Fort Smith	11⅓–15	25	7–8⅓	$1.00	35		35	25	20–25
Little Rock	12½–15	20–25	6⅔–8⅓	$0.80–1.00	30 40	20 30	30–35	25	25
Alabama:									
Birmingham	15–20	20–25	8⅓–10	.80–1.00	40	30	30–35	25–35	25–30
Mobile		25–30	8⅓–10	2.00 1.25		26 20	30–35		25–30
Montgomery		18–20	6¼–8	.80– .90	40	20	33	25–30	25–30
Florida:									
Jacksonville		25–30	8–10		40		33–35		28–30
Pensacola		35	10		40				
St. Augustine		32	10	1.20	40	30	35–40		25
Tallahassee			8⅓–10		40		35	25–30	
Tampa	25–27	35	9–10	1.00	40	20	35	35–40	30
Georgia:									
Atlanta	20–25	30	8⅓–10		30–40		30–35	25–40	
Augusta		25	10	1.00	40	25	32–35	30	30
Macon			8⅓	1.00	40	25	33	25–30	
Savannah		25–30	8⅓–10	2.00	50–60		35	25–30	25
Valdosta		30	10		25		35–40	25–35	
Kentucky:									
Covington			6–8	.80	24–30			25–30	
Lexington			6–8	.60	30	20	30–40		25–30
Louisville	11–15		7½–10	.60	30 25	25 20	30–35	12–30	27
Newport	18–20	25	7–8	.70	24–30		30–35	25–30	25
Louisiana:									
Baton Rouge		25	10		40		30–35		
New Orleans	14–16	20–25	7½–10	.80	30–40	20	32–35	30	
Shreveport		30	7½–10		50	25	35–40	25–30	
Mississippi:									
Jackson		25	7½–10	.75	25		30–35	15–30	
Meridian			10	1.00			35–37½	15–30	
Natchez		25	8–10	1.00	40		37½	25–30	
Vicksburg		24–32	8–10	.90–1.20			28–35	18–25	
North Carolina:									
Asheville		20–25	7–10	1.00 1.50		18–20 30	30–35	25–30	
Charlotte	15	25	10	1.20	40		35–40	7–35	15–30
Greensboro		17–20	6–10	.90–1.25	25–40		30–35	12–30	25
Raleigh		25	8⅓–10	1.00	50	25–30	30–35	25–35	
Wilmington			10–12	2.00	50–60		30–40	25–30	25–30
South Carolina:									
Charleston	20–24		8–10		60	30	30–35	25	25
Columbia		24	7–10		50		28–35	10–30	25–30
Tennessee:									
Chattanooga	13–17	25	7–8⅓	.80–1.00	35	20	35	20–25	25–30
Knoxville		20–25	7–8		32	20–22	30–35	25–30	
Memphis	14–17		7–10		25	20	35	25	25
Nashville	13–18		5–8	1.00	25–30	12½–30	30	28	
Texas:									
Austin		20–25	5–7½	1.00			30–35	10–30	
Dallas		20–25	8⅓	1.00–2.00	40	35	30–35	25–35	25
Fort Worth		20	7	1.00	30	25	27–30	8–30	20–25
Houston		20–25	7½–10	.75–1.20			30–35	20–30	
Galveston			6–10	.75–1.00			35	25–30	30
San Antonio	15–18	25	7–8	.75	30–40	25	25–35	10–30	15–30
Waco			5–7½	1.00	25		30–35	10–30	
West Virginia:									
Charleston		25	8–10		30		30–40	25–30	
Virginia:									
Charlottesville		24	6–8	1.00	30	15	30–35	20–25	
Lynchburg			10		25		33	20–25	
Norfolk			10		40		30–35	30	30
Portsmouth		25	8–10	.80–1.00	40				
Richmond	15–19	24–28	7–10	.85–1.00	40	25	35	15–35	

TABLE 5.—*Wholesale and retail prices of dairy products handled in 50 south cities, fiscal year 1905–6*—Continued.

City.	Oleomargarin, per pound.	Cheese.		Ice cream.		Buttermilk, per gallon.	Sk mi per
		Retail, per pound.	Wholesale, per pound.	Retail, per gallon.	Wholesale, per gallon.		
Arkansas:	*Cents.*	*Cents.*	*Cents.*			*Cents.*	*Ce*
Fort Smith	15–25	20–25	17	$1.00	$0.70	10–12	
Little Rock	15–25			$1.00–1.50	.65–.85	12½–15	
Alabama:							
Birmingham	15–25	20	16	1.50	.70–.90	10–15	
Mobile	15–25	18–20		1.25–2.00	1.00	10–12½	
Montgomery	15–25	19–20	14–15	1.00–1.25		10–15	
Florida:							
Jacksonville	20–25	20		1.50			
Pensacola				2.00			
St. Augustine	15–25	20	15	1.20			
Tallahassee		20	15	1.50		10	
Tampa		20		1.50	1.00	20	
Georgia:							
Atlanta		20		1.50–3.00		15	
Augusta		17½–20		1.50		12–15	
Macon	20	20	14½	1.25–2.00	.80–1.15	10–15	No s
Savannah		20	15				
Valdosta		20	15	1.60	1.20	15	
Kentucky:							
Covington						10	
Lexington	15–25	20	15–16	1.00	.75–.85	10	
Louisville	12½–25	18–20	16			15	
Newport	15–22½			1.50	1.00	10	
Louisiana:							
Baton Rouge	15		15	1.50	1.00	[illegible]	
New Orleans	15–25	20–25	15	1.50–2.00	.75–1.00	10–12	
Shreveport		20–25	14–17½	1.25–2.00		15	
Mississippi:							
Jackson	20–25	20	16	1.25–2.00	1.00		
Meridian		20–22½	15–16	1.50–2.00			
Natchez		20	16½	1.25–2.00			
Vicksburg	15	20					
North Carolina:							
Asheville		20			.80–1.25	[illegible]	
Charlotte	15–20	17½–20		1.30–1.50	1.00	[illegible]	
Greensboro		20		1.00		[illegible]	
Raleigh	15–20	17½–20		1.00–2.00		15	
Wilmington		20	15	1.50	1.00	20	
South Carolina:							
Charleston	15–25	20–22		1.40			
Columbia		20	16	1.50		10	
Tennessee:							
Chattanooga	25	20	15–16	1.25–1.50	.75–.90	10–15	
Knoxville	20	20	14–15	1.00–1.25	.75–1.00	10	
Memphis	20–25	20	14–15	1.25	.70–1.00	10	
Nashville	25	20	15	1.00–1.50	.75–.90		
Texas:							
Austin		20	15–16			10–15	
Dallas		20	15	1.00–2.00	.75–1.00	10–12½	
Fort Worth	12½–25	20	16	1.00–1.50	.75–1.00	10	
Houston	15–20	17½–20		1.00–2.00		15–20	
Galveston		18–25		1.25	.75–1.00	15–20	
San Antonio		20		1.00–1.50	.70–.80	12–15	
Waco				1.00	.50–.70	10	
West Virginia:							
Charleston	15–25	15–20		1.25		15	
Virginia:							
Charlottesville	12½–20	20	15	1.00–1.25	1.00	10	
Lynchburg	15	20	14–15	1.50	1.00	15–16	
Norfolk	15–32	18	14	1.50–2.00	.65–1.00	20	
Portsmouth				1.00–1.50			
Richmond	15–25			1.50	1.00	14	

THE MILK SUPPLY OF SOUTHERN CITIES.

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PRODUCTION.

Most of the milk supply of southern cities is produced within a few miles of the place of consumption. Many herds are kept within the thickly settled portions of the cities, where land is expensive. This generally means overcrowded stables, poorly lighted and ventilated, with contracted yards for exercise, filthy at all times, and almost knee-deep with mud after a rain. The feed used in these dairies is largely such as does not call for much storage space and is influenced to some extent by local conditions of production. Many city herds are fed nothing but cotton-seed meal and hulls. In some instances wheat bran is added. In cities where distilleries are located distillery slop is fed, though the trend of city ordinances is in opposition to this. Where there are breweries, brewer's grains are prominent in the dairy ration. Sometimes the grains are reduced to a thin slop with warm water. On account of the readiness with which the grains ferment some health boards prohibit the use of wet grains.

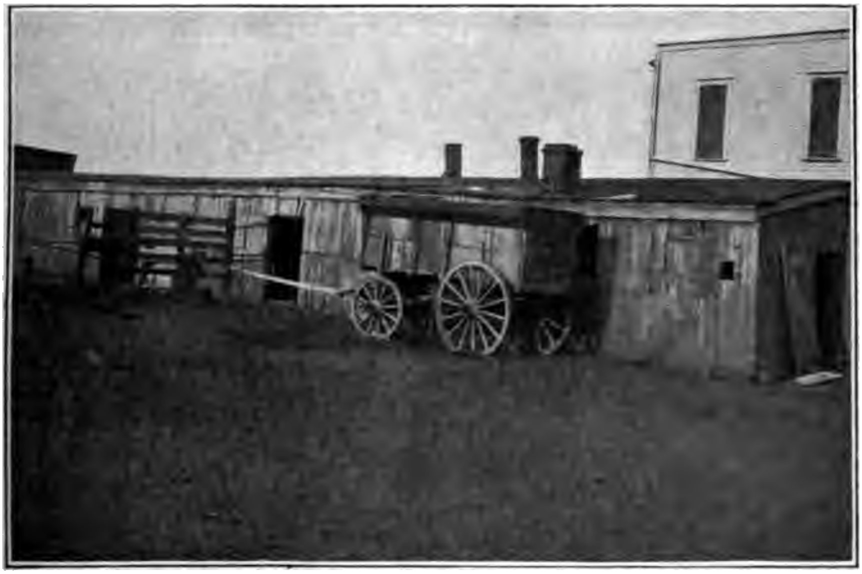

FIG. 1.—Cow stable in southern city, showing poor lighting and ventilation.

As the dairies are farther removed from the thickly settled portions of the cities to locations where land is less valuable the cows get more green feed in season, according to conditions. In some places a small bunch of green fodder of some kind is fed in the manger; in others the cows are allowed an hour's run each morning in a field of growing wheat. At still greater distances increasing amounts of green fodder are fed, though soiling as a system has made but little progress; and where the land is within an easy drive of the city and cheap enough there is some pasturage.

CARE OF MILK AT DAIRY.

Generally speaking, milk is not properly cooled by producers. The use of ice is unknown among the ordinary dairies. Some producers run the milk over a cooler supplied with spring water of a temperature rarely below 65° F. and frequently as high as 75°. Others set the cans of milk in tanks of spring water or in the running spring water. Other dairymen make no pretense of cooling the milk and can or bottle it for market at the natural animal temperature. The cooler, when used, sometimes stands in the stable (fig. 2), and frequently the milk is strained into the shipping cans behind the cows. Bottling is often done in rooms connected with the stable or in places where cleanliness is impossible (fig. 3).

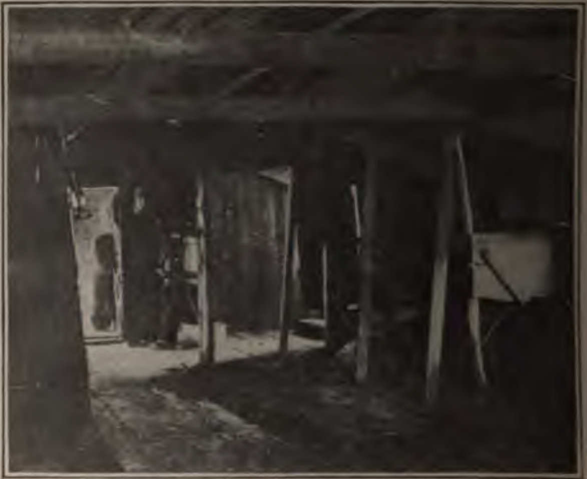

FIG. 2.—Insanitary location of milk cooler in barn.

Because the climate is generally mild and at times very warm much work is done out of doors. This frequently results in insanitary ways of handling milk utensils and the milk itself. For instance, when water for cleansing utensils and bottles is heated in an old pail set up out of doors on a few loose bricks the presumption against proper sterilization of milk receptacles at that dairy is strong. Many dairies were found where the "milk room" was an open porch of the dairyman's residence (fig. 4), sometimes very disorderly and sometimes also the place where most of the domestic kitchen work is done, and in one case where hens were sitting. Milk receptacles will hardly be cleansed in a sanitary manner under such conditions, to say nothing of the exposure of the milk to impure air in straining and bottling.

DISTRIBUTION.

Most of the milk supply is retailed and distributed by the producers. Very little milk is transported by railroad in the South, and comparatively few cities have milk plants or depots owned by middlemen. Such establishments are found, however, in Macon, Atlanta, and Savannah, Ga.; Asheville, N. C.; Richmond, Va.; New Orleans, La.; Knoxville and Memphis, Tenn.; San Antonio, Fort Worth, and Austin, Tex.; and Fort Smith and Little Rock, Ark. Nearly all of the establishments in these cities pasteurize their entire output. Most of the milk is bought by the gallon, but some buy on a butterfat basis. In Savannah and Memphis the establishment of the plants grew largely out of a movement on the part of the producers to relieve themselves of the expense and trouble incident to doing a retail business. On account of climatic conditions two deliveries a day are frequent, milk often reaching the consumer less than five hours old. Bottles are used to a limited extent. (See Table 4.) The custom of dipping milk from the open can prevails somewhat, and in many

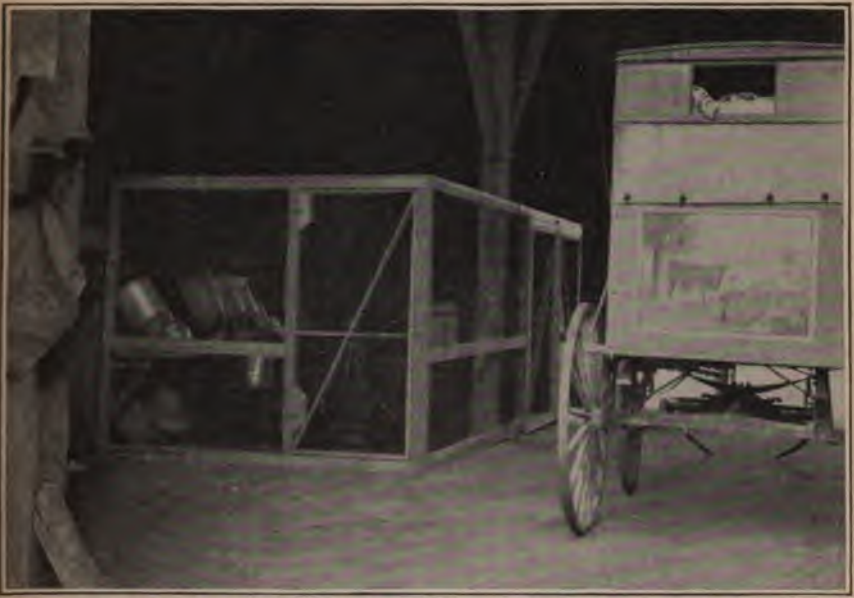

FIG. 3.—Milk room made by partitioning off with wire netting a corner of wagon house.

instances milk is drawn through faucets from large carriers. In a few cases the milk is poured from a two-gallon can provided with a cover which is also a measure, and in a few cities it is delivered in a varied assortment of tin cans and earthen jugs. Milk is usually delivered from wagons built especially for the business. In New Orleans high two-wheeled carts are used, the carrier faucet-cans being placed in the front part.

QUALITY.

The quality of the market milk is generally satisfactory so far as amount of milk solids is concerned. In many instances it is much above the legal requirement. The Memphis city chemist says that the milk supply of that city will average from 4.5 to 5 per cent of fat. Jersey blood is prominent among the dairy herds.

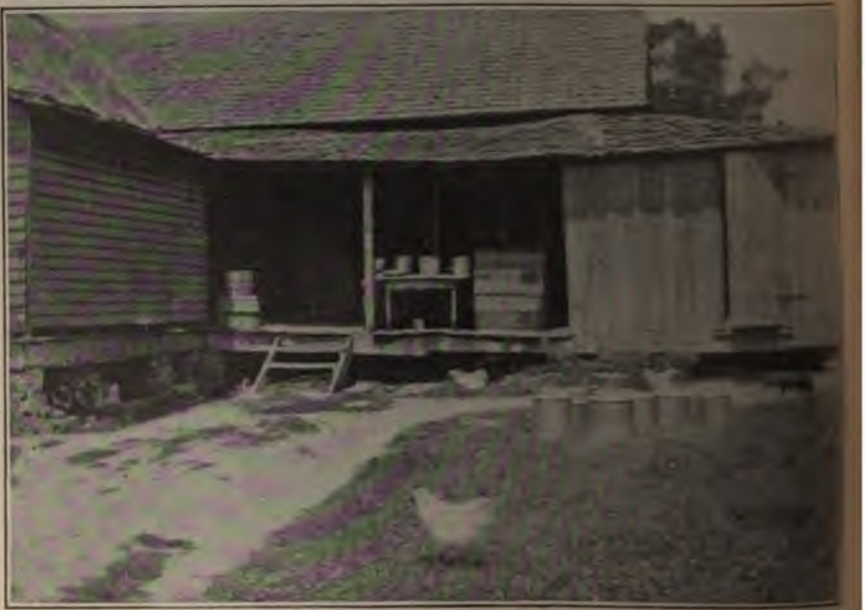

FIG. 4.—Porch of residence used as milk room; utensils drying and airing on lawn with chickens and pigs.

As regards cleanliness and freedom from bacterial contamination the South has its share of the ignorance and negligence to which is due so much unsatisfactory market milk. In addition to this, some climatic and economic conditions have a peculiarly unfavorable bearing. Many producers are renters, doing a small business and struggling hard to make a living. Frequently they have poor barns and milk houses as well as inadequate facilities for handling the milk and washing the utensils. (See figs. 5 and 6.) In many cases the wife and children have to lend a hand in the dairy work. All these conditions are not only bad in themselves, but they have a tendency to crush any ambition to improve. The scarcity of ice prevents the proper cooling of much milk. Considerable quantities are therefore handled and sold at a high temperature, promoting rapid increase of bacteria.

A certified milk commission exists in Louisville, Ky.

PRICE, SUPPLY, AND DEMAND.

In many cities 10 cents a quart is the prevailing retail price of milk to the consumer. In some places only a few of the better dairies get 10 cents a quart, while many of the others take any price that is offered—as low as 5 cents a quart in a few instances. A common price is 6¼ cents a quart, 4 quarts for 25 cents.

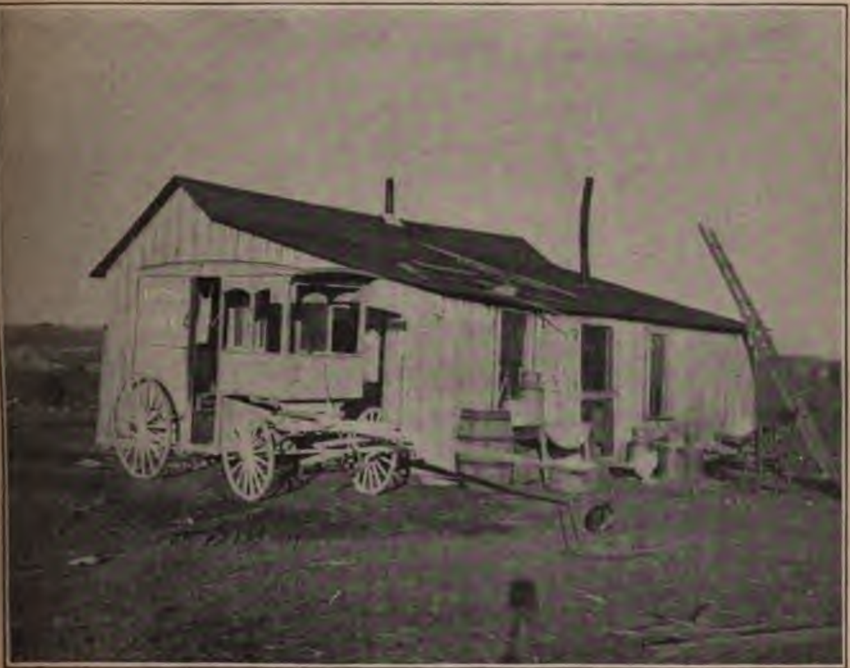

FIG. 5.—Residence of small dairyman containing milk room; milk cans exposed to chickens.

Generally speaking there is no oversupply, and in many places milk is actually scarce at times. In spite of this complaints are made of the competition in the business, chiefly among dairymen whose conditions are ordinary to poor. Prices are frequently cut where the ticket system prevails by giving a few extra tickets for a dollar. Twenty-eight pint tickets for $1 is a common price, which is about 7.2 cents per quart; but in some instances the thrifty housekeeper by skillful bargaining can get 30 or even 32 tickets, the dealer insisting that his price remains at 28 tickets and that the extra ones are a gift. Complaint is made in some places, notably Memphis, of uneven production, and of competition from small summer dairies in which the cows are milked for only such time as they can be kept on pasture. This "grass milk," cheaply produced, is sold at almost any price, and depresses the market for a few weeks each year, leaving some of the regular all-the-year dairies with a temporary surplus.

In some places there is a shortage, which compels the use of much condensed milk. Some of the large hotels are compelled to keep a stock of condensed milk on hand to be sure of an ample supply. In Florida complaints came to the writer from consumers concerning the inadequacy of the supply and the resultant independence of the milk producers and dealers. One Jacksonville business man with a "bottle baby" had milk delivered in the morning by one milkman and in the evening by another—double what he needed—to insure a supply should one or the other happen to omit his regular call.

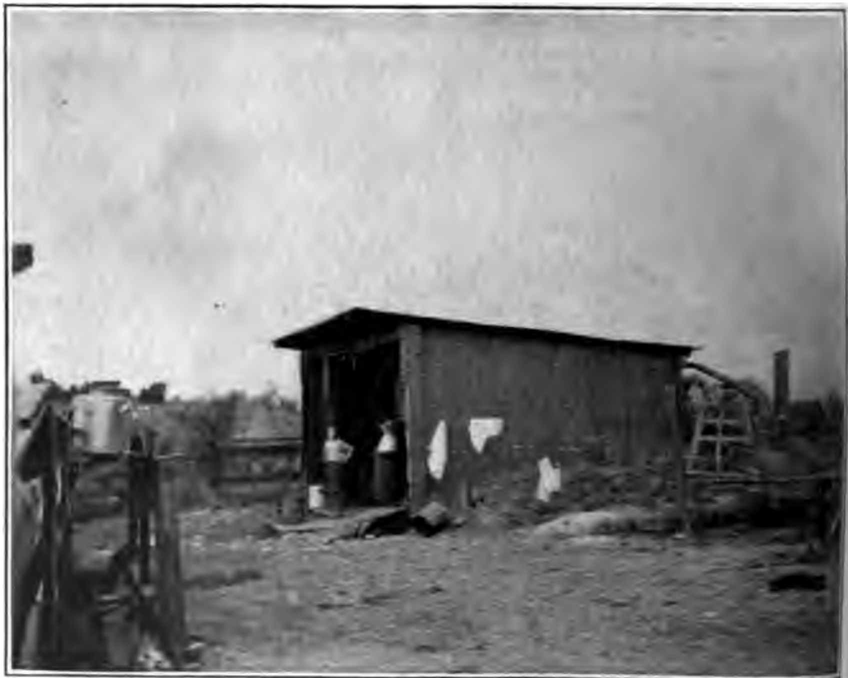

FIG. 6.—Milk house with one side open; work done by children.

INSPECTION.

Many cities have milk ordinances, though in not a few cases very little is done to enforce them. In some cities the collection of license fees and the issuance of permits for the sale of milk is the extent of milk inspection. Many cities had no inspection of any kind until a short time ago.

During the past year a campaign for better milk was taken up in Texas by a leading magazine. Representatives of the publication were sent to the seven largest cities of the State, and samples were taken of the milk as delivered by the dairymen. Thirty-five out of 53 samples, or 66 per cent, were found to contain preservatives. Some of the samples were also low in butterfat, indicating the addition of water or partial skimming. Within a few weeks after the publication of the magazine article showing these facts the municipal authorities in several of the cities began a warfare against adulterated milk.

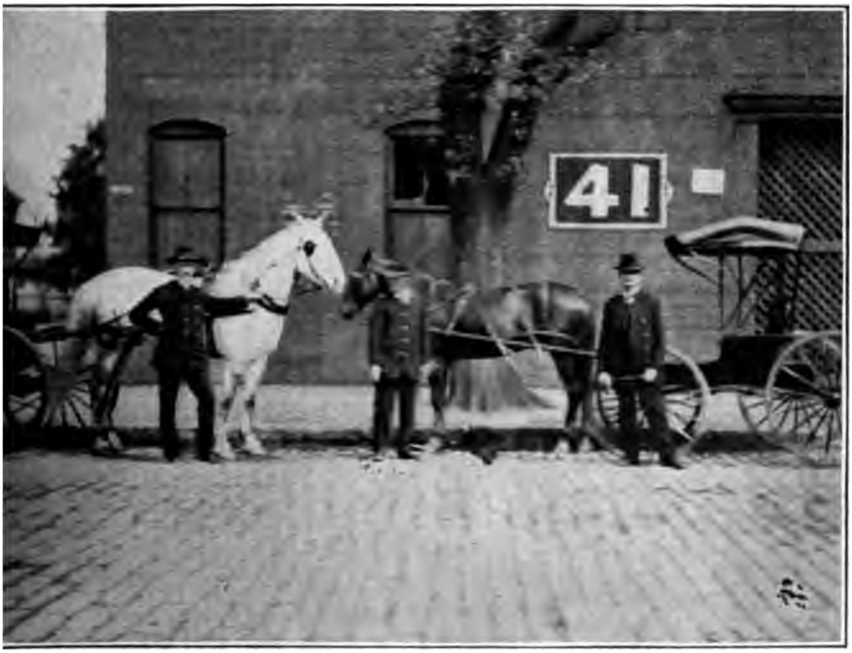

FIG. 7.—Uniformed milk-inspection corps, Atlanta, Ga.

Where ordinances have been in existence and have been enforced, the work under them has related largely to securing evidence of the sale of adulterated or under-standard milk, and in some places excellent work has been done along these lines, greatly improving the composition of the city supply. But in at least one city, where the custom of drawing milk from large cans prevails, samples are taken only from those carriers, and no effort is made to sample milk as delivered to the consumer, though it is a matter of common knowledge that this manner of distribution results in a very uneven product, many customers getting only skim milk.

The sanitary side of dairy inspection has received too little attention, but a gradual improvement in this direction is noticed. In Charleston, S. C., a code of laws was recently adopted and a milk inspector appointed. Considerable attention is given to the sanitary inspection of stables and methods of handling milk, with encouraging results. In Savannah, Ga., an outbreak of typhoid fever, traceable to a leading dairy, has called attention to the importance of supervising the milk supply, and an agitation for more inspection is under way. In Asheville, N. C., a milk inspector was recently appointed, and already there has been a radical cleaning up of some of the worst stables and an improvement in others. In Nashville and Memphis, Tenn., the county health officers have taken a new interest in the sanitary inspection of the dairies under their jurisdiction. Columbia, S. C., is agitating for milk ordinances and inspection. The Galveston, Tex., health office now gives a special certificate to all dairies whose apparatus, dairy rooms, and herds come up to a certain standard of cleanliness. Atlanta, Ga., has uniformed milk inspectors who are furnished with buggies. (See fig. 7.) This city has recently adopted radical ordinances and greatly improved its milk [illegible]. These ordinances, among other things, provide that—

> All milk shall be strained as soon as milked.
>
> All milk must be offered for sale as milked from the cows, and shall [illegible] passed through cream separators or other apparatus other than strainers [illegible] the purpose of removing manure, dirt, or other substance.
>
> All milk shall be marketed as soon as possible after milking.
>
> It shall be unlawful for any person to bring or receive into the city of Atlanta for sale, or to sell any milk which contains any manure or dirt (that [illegible] quantity sufficient to be detected with the naked eye after milk has [illegible] standing for one hour or more).

In Louisville, Ky., the activity of the State food inspection officials has succeeded in prohibiting the sale of milk from swill-fed dairies in that city. This war against milk from cows fed on distillery slops has had a good effect upon the milk supplies of the other cities of that State.

COST OF PRODUCTION.

Several factors tend to increase the cost of producing milk in the South. In the first place, but little attention seems to be given to keeping dairy cows which produce large amounts of milk, consequently few cows are kept which are large producers. In some instances Jersey blood predominates, but of families which are small producers. Many herds were found giving only about 5 quarts per day per animal. In other cases cows of the beef type are bought at the stock yards when about to freshen; these are milked through one period of lactation, then fattened, and sold for beef. Rarely does one find a herd of cows of dairy type selected or bred for the largest possible production of milk with 3.5 to 4 per cent fat.

Secondly, considerable work is done in an uneconomical manner. On account of the warm climate two deliveries per day are frequent, which means doubling this item of expense. The double time of man and team, and wear and tear of horse and wagon, must frequently more than offset the saving of ice, to say nothing of the inferior quality of the product. When milk is cooled in a spring the spring house is often at a distance from barn and residence, necessitating many additional steps and increasing the cost of production. The saving of steps seems to be an idea impossible for many persons to grasp.

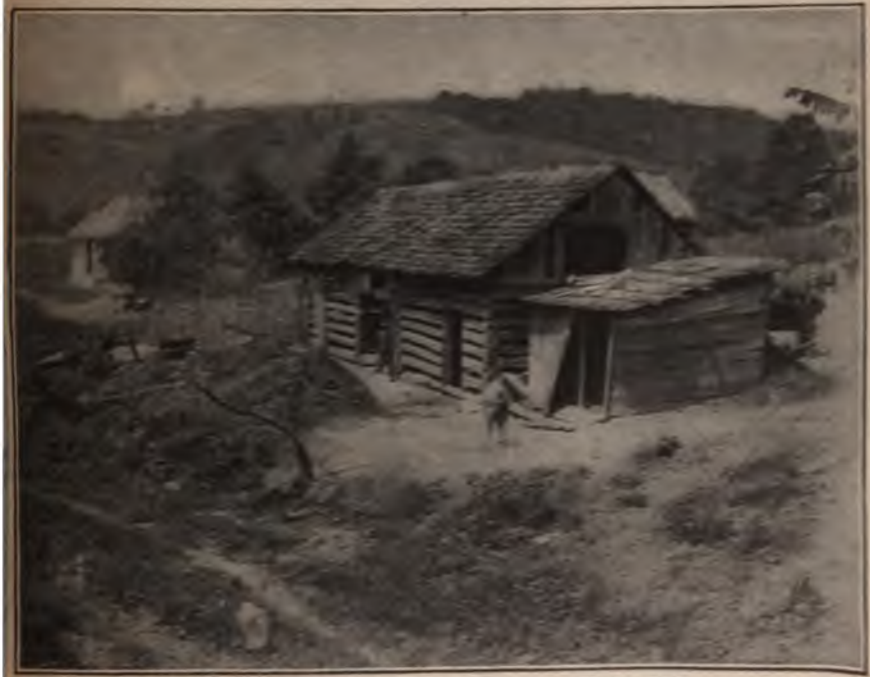

FIG. 8.—Stable affording inadequate protection to cows during inclement weather.

Thirdly, many southern dairy barns are unsuited for the most profitable production of milk on account of the fact that cows can not be kept comfortable in them at all times. In a country where much of the winter weather is mild the dairyman is apt to overlook the fact that even a brief chill to the delicate organism of a sensitive dairy cow damages the animal and shrinks the milk flow, which may be very expensive; the full flow of milk may not be regained for months. Consequently, where the temperature may drop as low as 40° F. even for only a few days in the year, or where damp chilly winds may bring discomfort to unprotected cows, even though for only a few hours, the stables should be so constructed as to protect the animals from the full force of the elements; otherwise the production is liable to drop in amount at almost any time. (See figs. 8 and 9.) Figure 10 illustrates a good type of southern barn which affords protection against inclement weather and at the same time provides light and ventilation.

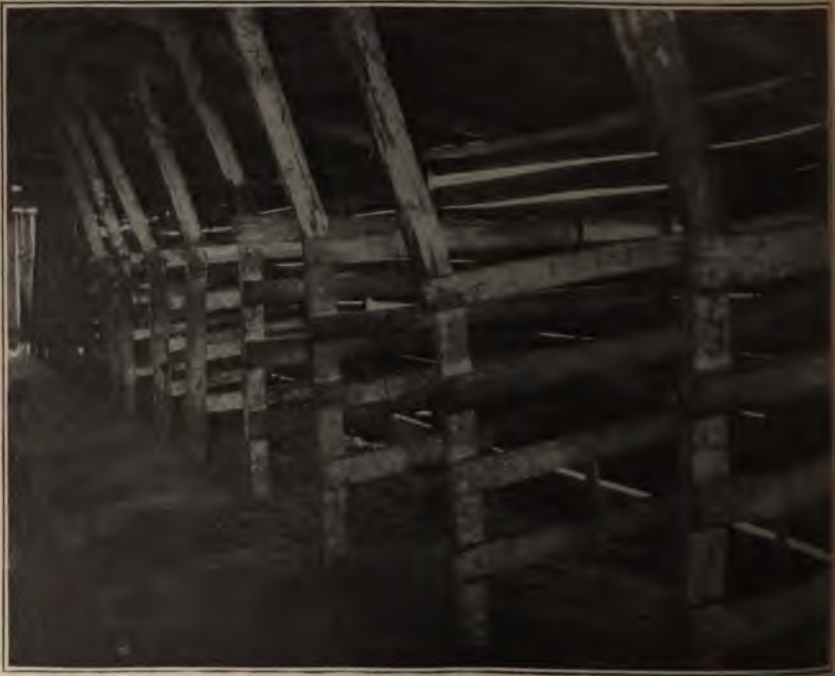

FIG. 9.—Interior of stable which does not protect cows against bad weather.

BUTTERMILK.

Large quantities of buttermilk are consumed in southern cities—Birmingham, Ala., being notable in this respect. It is everywhere popular as a beverage, and is always on the menus of hotels and restaurants; it is also used extensively in cooking, many families buying it by the gallon. The price ranges from 10 to 20 cents a gallon, 15 cents being about the average. In a number of places it is claimed that nearly as much buttermilk is consumed as whole milk, but exact figures as to the consumption of buttermilk can not be obtained.

Many buttermilk dealers have small dairies of 2 to 6 cows and go to market at irregular intervals with varying amounts of butter and buttermilk, and some cities do not require permits for the sale of buttermilk, hence there is much difficulty in determining the amount consumed.

Buttermilk dairying is popular with some producers, who claim that the income from the buttermilk and butter is almost as much as from whole sweet milk, without the necessity of daily delivery, the annoyance of inspection, and the expense of keeping the dairy up to the standard of cleanliness required for a sweet-milk dairy. But health officers are giving increased thought to buttermilk dairies, and doubtless in the near future a more careful buttermilk inspection will be demanded. Complaints of ptomaine poisoning alleged to have been due to buttermilk have come from Nashville, Tenn., and elsewhere.

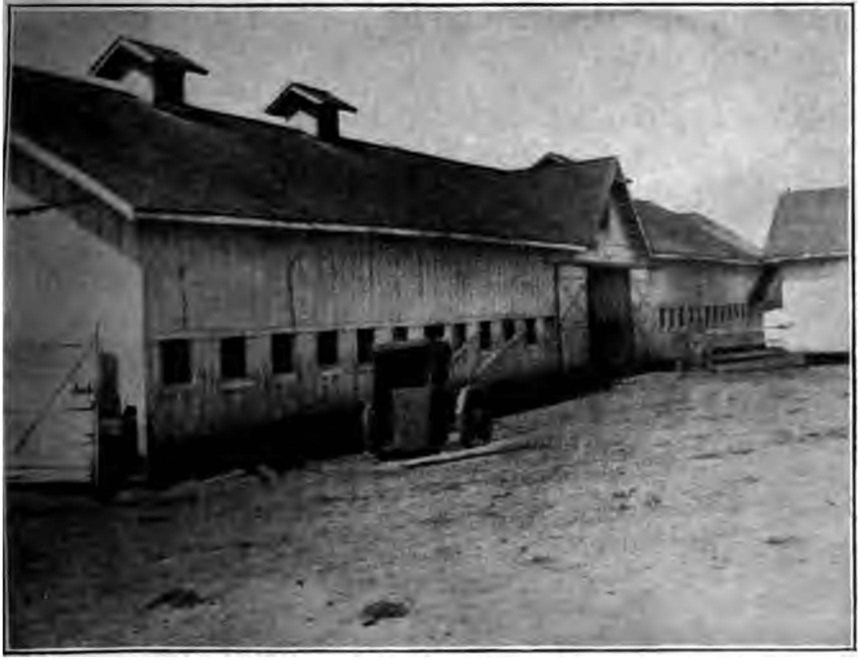

FIG. 10.—A good type of southern barn.

OPPORTUNITIES FOR IMPROVEMENT.

The southern market-milk situation is capable of much improvement. The dairymen can reduce the cost of production very materially by keeping cows better adapted for market-milk production, by studying economy of labor, and by using more cheap home-grown feeds suitable for milk production. Again the situation is capable of great development by an increased consumption. The per capita milk consumption in the South is below the average for the country. The per capita daily consumption of milk in the United States is estimated at about two-thirds of a pint; in Boston, Mass., it is eight-tenths of a pint; and as high as 1 pint is reported from some cities. On the other hand, in most southern cities the daily consumption is less than half a pint, and as low as one-third of a pint is named in some places. This showing may be somewhat misleading because of the large amount of buttermilk used, which doubtless takes the place of some sweet milk; but even if liberal allowance is made for this, the fact remains that the South consumes less than the average amount of milk. Moreover, the use of cream, of which large amounts are consumed in the North, is almost unknown in the South.

Several reasons for this low per capita consumption of milk and cream can be given: Indifference as to the food value of milk, an inherited habit of using milk in small quantities, an insufficient supply, suspicion of the purity of the product, and the large negro population. The latter consumes little or no milk, but materially increases the divisor to be used in ascertaining the per capita consumption. The last-named factor is, of course, purely sectional; but as regards the others, experience in different northern cities and towns has shown that an abundant supply of milk of unquestioned quality tends to increase the amount that is used; also that a campaign of education among producers helps consumption. Hence we may assume that when the milk supply of southern cities is improved by means of better sanitary inspection, and when the public realizes that an ample supply of clean, safe milk can be obtained, increasing amounts will be consumed.

Here is another opportunity for improving the condition of the southern dairyman. As the public is educated to realize the difference in the way good milk is produced as compared with the inferior article, there will be a willingness not only to consume more of that which is produced in the proper manner, but also to pay a higher price for it, as for a high-grade article. Already in Memphis and Nashville, Tenn., Asheville, N. C., and other places some dairies easily get 1 to 4 cents a quart more than others merely because the public has confidence that the product is pure and clean.

WHY DAIRYING IS UNDEVELOPED IN THE SOUTH.

By B. H. Rawl,
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CONSUMPTION AND PRODUCTION.

The extent of the market for the various kinds of dairy products in the South has been shown in Table 4 (page 14), where data are given from 50 cities distributed throughout 13 States. The amounts of dairy products mentioned in Table 6, which are handled in these 50 cities, are far greater than the total amounts of those products produced in the 13 States in which the cities are located. The extent of production in these States and the difference between this home supply and the market demand are shown in the table below. This table is a partial summary of Table 4, with some additional matter:

Table 6.—*Products handled in 50 southern cities, and estimated financial gain if produced at home.*

Product.	Quantity imported into 50 southern cities.	Amount produced in 13 Southern States.[a]	Average retail price.	Value of imported product.	Cows needed to supply deficiency.[b]	Cost of keeping cows at $45 a year.	Estimated profits that could be saved to the South.[c]
	Pounds.	*Pounds.*	*Cents.*	*Dollars.*	*Number.*	*Dollars.*	*Dollars.*
Creamery butter	23,434,941	890,768	33½	7,850,705	69,747	3,138,615	4,712,090
Renovated butter[d]	7,162,701	33,260	26	1,862,302	21,317	959,265	903,037
Cheese	41,582,545	782,000	20	8,316,509	69,304	3,118,680	5,197,829
Condensed milk[e]	42,560,688	....	10	4,256,069	14,187	638,415	3,617,654
Oleomargarin[f]	3,361,483	522,900	20	672,297	10,004	450,180	222,117
Total				22,957,882	184,559	8,305,155	14,652,727

[a] Census of 1905.
[b] Cows giving 6,000 pounds of milk or 336 pounds of butter.
[c] Cost of manufacture not deducted.
[d] Report of 39 cities.
[e] Report of 49 cities.
[f] Report of 40 cities; amount consumed in the 13 States, 6,766,221 pounds.

It will be noticed from the above table—

1. That the value of the dairy products shipped into these 50 cities (not including similar products that are shipped into other cities of those States) is $22,957,882, or an average of $459,157 per city.

2. That 184,559 cows, each giving 6,000 pounds of milk, or 336 pounds of butter, would be required to produce these products.

3. That after allowing $45 per cow for the cost of feed there would still remain, on the basis of retail prices given in Table 5, a profit of $14,652,727, or an average of $293,054 per city (cost of delivery not considered).

4. That 12,304 dairy farms, or an average of 246 farms per city, with 15 cows of the kind above named on each farm, would be required to supply these products.

5. That after allowing for the cost of the feed at the rate above given there would remain a profit of $1,191 per farm (the by-products of the dairy—calves, manure, skim milk, etc.—paying for the labor).

6. That each of these farms would require two men to operate it, hence giving profitable employment to 24,608 men, or an average of 492 men per city.

7. That since these dairies would greatly facilitate the growth of all kinds of crops, their development would tend to increase rather than decrease other agricultural products in that section.

There are hundreds of farmers throughout the South, each of whom could add a 15-cow dairy to his farm, and could besides in a short while easily produce more of other crops than he is producing at present.

WHY SOUTHERN DAIRYING IS UNPROFITABLE.

Dairying is undeveloped in the Southern States largely because the farmers of that section do not understand how to make it profitable. They realize the necessity of more fertilizer for their farms, and they are buying large quantities of it at high prices. They realize, too, that barnyard manure is superior to commercial fertilizer, but they do not understand how to keep the cattle to make the manure without sustaining a loss on the cattle.

This is due principally to three things: (1) The cattle now kept are, as a rule, inferior and could not be kept profitably under any circumstances; (2) many dairymen buy practically all their feed instead of growing it, especially those who live near the city and can get a good price for their products; and (3) the dairyman who lives some distance from the city and sells butter as a rule makes an inferior product. A very large per cent of the dairies in the Southern States are suffering from at least two of these difficulties and in many cases from all three.

Low Average Production Per Cow.

In the 13 States named in Table 4 the average cow, according to the census of 1900, produces annually only 3,036 pounds of milk, which it is estimated will average 4.8 per cent of butterfat, and will therefore make 145.7 pounds of butterfat, or about 170 pounds of butter. In the following two tables the returns from this average cow are compared with the returns from a good cow. The standard adopted for the good cow—6,000 pounds of milk, making 288 pounds of butterfat—is reasonable, since in some herds in the South each cow in the herd has exceeded it in her average.

The tables show the average amount received under each of the three methods of marketing commonly used in that section. The prices given are averaged from Table 5.

Table 7.—*Estimated net returns from an average southern cow in one year under three methods of marketing.*

Method of marketing.	Milk produced.	Average price.	Amount received.	Cost of feed.	Net returns.
	Gallons.				
1. Producer sells whole milk retail	353	8.6 cents per quart	$121.43	$40	[a] $46.13
2. Producer sells whole milk to dealer.	353	17 cents per gallon	60.01	40	20.01
3. Producer sells dairy butter—[b]					
145.7 pounds butterfat making 170 pounds butter.		25.8 cents per pound	43.86		
Leaving 2,890 pounds skim milk.		20 cents per 100 lbs.[c]	5.78		
Total receipts from butter making.			49.64	40	9.64

[a] After deducting $35.30 for cost of delivery at 10 cents a gallon.
[b] Using 4.8 per cent as fat test.
[c] Estimated value for feeding purposes.

Table 8.—*Estimated net returns from a good cow in one year under same three methods of marketing given in Table 7.*

Method of marketing.	Milk produced.	Average price.	Amount received.	Cost of feed.	Net returns.
	Gallons.				
1. Producer sells whole milk retail	[a] 698	8.6 cents per quart	$240.11	$45	[b] $125.31
2. Producer sells whole milk to dealer.	698	17 cents per gallon	118.66	45	73.66
3. Producer sells dairy butter—[c]					
288 pounds butterfat making 336 pounds butter.		25.8 cents per pound	86.69		
Leaving 5,712 pounds skim milk.		20 cents per 100 lbs.[d]	11.42		
Total receipts from butter making.			98.11	45	53.11

[a] Six thousand pounds, or 698 gallons.
[b] After deducting $69.80 for cost of delivery at 10 cents per gallon.
[c] Using 4.8 per cent as fat test.
[d] Estimated value for feeding purposes.

Dairying is to a large extent restricted to an area around the cities. Table 7, which represents actual conditions, will show the cause of this fact. The average cow in a dairy herd located so that the milk can be delivered direct to the consumer earns $46.13 a year, after paying for feed and delivery; if this cow's milk is made into butter she earns $9.64 after paying for feed (no allowance being made for farm labor in either case). From these facts the average dairyman would decide that supplying retail milk is the more profitable. As a matter of fact there is little profit in either one. The man who is retailing milk often has no farm, therefore has no use for manure and does not take care of it, and being located near the city labor is more expensive. The man who sells butter perhaps has a farm, and therefore his feed may cost less than $40 per cow; then, too, if he clears nothing more than the manure, this may enable him to make his farm very profitable for other things; such cases are not uncommon.

In cases where milk is sold wholesale (2, Table 7) it would appear that some advantages exist. In such cases the dairymen usually own farms, and a few of them have made money. Still there are disadvantages to be contended with. The profit is greater than in butter making (3, Table 7), but no allowance is made for expense of shipping, there is no skim milk, and on the whole perhaps no can be said for this class than for the other two. They are al large extent failures.

Different Results with High-Class Dairy Cows.

Where, then, are the successful dairies found? They are i classes represented in Table 8. In this table each of the class an excellent showing for a profit, if reasonably good business me are used.

In comparing Table 8 with Table 7 it will be seen that i former $45 is allowed for the cost of feed, as against $40 in Ta If the methods used in both cases were the same the difference s perhaps be greater; in other words, $40 would probably be more is necessary to feed the average cow. But it is safe to assume such is not the case, because the man who does not know enou keep cows that are above the average, as a rule, does not know en to feed them most economically.

In continuing this comparison it will be noted: (1) That allowing for feed and delivery there remains from the retailin the milk $125.31 in the case of the good cow, as against $46.13 fo average cow; (2) that after allowing for feed there remains fro wholesaling of the milk $73.66 in the case of the good cow, as ag $20.01 for the average cow; and (3) that after allowing for feed adding the value of the skim milk there remains from the sale o butter $53.11 in favor of the good cow, as against $9.64 for average cow.

The question that naturally arises from a comparison of Tab and 8 is, Why will any man keep such cattle as are represente Table 7 when he can make so much more profit with better cattl shown in Table 8? There can be no answer other than that i because of a lack of knowledge. According to the census of 1 there were 4,097,961 cows in the States named in Table 4. These c were annually producing 1,444,291,536 gallons of milk, or 596,203 pounds of butterfat. If these cattle were of the class shown in Ta 8, they would produce 2,859,042,558 gallons of milk, or 1,180,212 pounds of butterfat; an increase of 1,414,751,022 gallons of m or 584,009,222 pounds of butterfat. Valuing this milk at the av age wholesale price given in Table 5, this increase would be wo $240,507,674; or valuing the butterfat in this milk according to wholesale rate in the table it would be worth $175,785,776.

In other words, the dairymen are annually losing not less th $175,786,776 because they are keeping cows that produce an aver of 353 gallons of milk per annum instead of cows that will prod 698 gallons, or 6,000 pounds, per annum. This is too important item for the dairyman to overlook; and it is certainly one of the most important causes of the present undeveloped condition of the dairy industry in the Southern States.

HOW TO GET GOOD COWS.

In considering this question, the source whence dairy cattle are obtained is of paramount consideration. It is true that the southern dairies are to a large extent in the vicinities of the cities, therefore, as has previously been shown, it is more profitable for them to sell whole milk. Skim milk as well as the facilities of the farm are lacking, consequently the raising of calves becomes a difficult and expensive operation. As a result the majority of such dairymen rely entirely on the market for their supply of cattle. In the interior country districts there is usually very little dairying, hence the supply of dairy cattle in those districts is very limited. The stock yard therefore becomes the only source of supply of cattle for a very large proportion of the dairies. Cows that are in milk are purchased, and when they go dry they are again sent to the stock yard. This practice is one of the essential causes of the low average milk production of southern cattle.

But in addition to this practice, those who do raise dairy cattle usually breed their cows to inferior, scrub, or grade bulls, and ignore the performances of the individual cows. These customs will surely prevent any marked improvement of the herd. Three things are recognized as essential by all successful breeders of dairy cattle: (1) Systematic records should be kept of all cows so as to determine which are profitable; (2) a purebred bull, well selected, should be used; and (3) the heifer calves from the best cows only should be retained in the herd. Some of these heifers will prove to be inferior individuals, and should be disposed of; but if the system is consistently carried out it will produce gradual improvement in the herd, regardless of what grade of cattle was used to begin with.

But even this does not solve the problem for the man who has neither farm facilities nor skim milk with which to raise calves. What, therefore, can he do? First, under average conditions, he should either buy a farm or get out of the dairy business. This is particularly true of the Southern States, where so much feed can be produced at a comparatively small cost, and where good pastures can be maintained for a great part of the year. But when the farm has been procured, how will the skim milk be obtained which is so essential in raising calves? This is an important consideration, and can often be provided for in the following manner:

There is a great demand for sweet cream throughout the South, which is often either supplied from the North or remains unsupplied. As it commands a very good price, very often such cream will bring as much as the whole milk from which it was taken. Therefore a whole-milk business can often be converted into a sweet-cream business without reducing the income from sales, and thus the skim milk can be retained at little or no cost. Sometimes it may be best to separate the cream from only enough of the milk to provide a sufficient supply of skim milk for the calves, and then sell this cream to the same customers who buy the whole milk. Even if a small loss in the sales is at first sustained by this system, it must be remembered that good cows are absolutely essential to a profitable dairy and that the increased production which will result from this system will soon offset any loss that was sustained at first in putting it into practice.

FEEDING.

In order that cattle may produce the most milk and do it most economically, they must have suitable feed, not all of which can be obtained by buying on the market. Green feed is very essential, and when it is not available direct from the field it should be supplied in the form of silage. It is impracticable to go into a discussion of feed in this paper, but too much emphasis can not be given to the matter of preparing the right kind of feed. In many cases the cows are fed on nothing but cotton-seed meal and hulls. This is not only an expensive feed, but it is entirely insufficient to give the best results. When used in combination with silage and good hay, cotton-seed meal particularly can be used to good advantage. Another very bad practice in connection with feeding is that the cattle are often not fed enough. Many a good cow is producing far less than her maximum because of an insufficient amount of feed.

As mentioned elsewhere, the inclination of the dairyman to rely entirely upon the market for his supply of feed is a very great drawback to the dairy industry of the South, and is a bad practice in two ways: (1) It is impossible to supply entirely from the market the kind of feed that is best for the cows, and (2) even if a suitable feed could be obtained from the market, it would be more expensive than if grown on the farm. All rough feed, at any rate, and in some cases a part of the grain, can be grown to great advantage. With the great variety of forage crops, particularly legumes, that are available under southern conditions, the production of feed is neither difficult nor expensive, and yet in this section the dairymen are producing less feed than in almost any other part of the United States. The southern dairyman can never fully succeed until he produces more of his

Pastures can be made that will furnish good grazing for the greater part of the year. There are two reasons why pastures should be used liberally, namely, the long pasture season, and the cheap lands; yet comparatively few southern dairymen have proper pastures. The waste lands of the farms that are covered with ditches and pine saplings are often fenced, but no further improvement is made; such pastures are little better than useless.

INFERIOR BUTTER.

There is in the South a large amount of butter sold to the renovated-butter factories as packing stock. This as a rule does not come from the dairies, but much of the dairy output also would be thus sold if the butter market were as discriminating as it is in some sections. The above-mentioned packing stock is what is commonly called "country butter," and comes from farms where one or two cows are kept for family use, the surplus butter being sold to a near-by grocery store. The stores are compelled to purchase such butter to retain the trade of those who sell the butter. Often the stores can retail this butter at once to other customers, but what can not be disposed of in this way is packed in barrels and when a sufficient amount has accumulated it is shipped to some renovating factory. Thus it is that this country butter often sells for from 7 to 15 cents a pound when good butter is retailing at an average price of 33¼ cents per pound (1907 prices). This discrimination on the part of the consumer is not against the producer, but instead is against an inferior article which the consumer will not accept, and which must, therefore, be sold as packing stock. This may seem like a very small item to the individual farmer who is producing such butter, but the practice is costing the farmers of the South in the aggregate an immense sum of money annually. The remedy for this practice is for those who are producing such butter to study the subject of butter making until a good article can be made. It is often true also that those who are producing packing stock are of the opinion that this butter is as good as can be made and that there is some other cause of such discrimination against their product. Every farmer who is conducting his work in a business-like manner must look after such details.

In Tables 7 and 8 butter production is shown to be the least profitable of the three kinds of dairying mentioned. But since this kind of dairying can be done anywhere, irrespective of the location of the market, it is by far the most important branch of the dairying of the South. When properly conducted it can be made very profitable, and there are a number of examples in various places that prove this. On these farms a dairy house suitably equipped for making butter on a small scale is provided at little cost, and when the proper methods are used excellent results are obtained. A small number of such plants are producing butter that always sells for the highest market price. When results are not satisfactory it is usually found that bad methods are practiced. It is hoped that the better kind of dairying will grow more in favor with the southern farmers.

HIGHER PRICES FOR BETTER MILK.

In the preceding article it is shown that the sanitary conditions surrounding the milk supply of many cities in the South are bad; hence dangerous milk is the result. There is now a great movement in progress throughout the whole country to improve the milk supply. To accomplish this it is often considered necessary that a higher price be paid for a better quality of milk, because the cost of producing it is greater. While this is generally the case, it is notably true that in some cities where prices are highest the quality of the milk is poorest.

It is also true that very unprofitable dairies often get the same price for their product as very profitable ones that are operating under exactly the same natural conditions. While quality in milk must be appreciated by the consumer and paid for, still there is usually something needed in addition to higher prices.

SUMMARY.

Some of the improvements which the situation demands have been suggested in the foregoing pages, and these are briefly reviewed in the following summary:

1. There is no branch of agriculture that is more needed in the South than dairying. It is not only a profitable industry in itself, but it may be made the means of increasing the productiveness of the soil and promoting a better type of agriculture.

2. It is found that southern dairymen, as a rule, are not using the most economic methods in the following particulars: (*a*) The production of the average cow is only about half what it should be. (*b*) Too many of the dairies are in the cities, when they should be on the farms; hence too high-priced feed and bad methods of feeding. (*c*) Milk and butter of poor quality are produced, which do not bring the highest prices.

3. It is strikingly true that in most cases where an inferior dairy herd has been in existence for some years it will be found that expensive methods are being practiced and an inferior grade of output is being produced.

4. Southern dairying needs improvement all along the line. The cost of production is unreasonably high, the sanitary conditions are often bad, and the price of first-class products is in some cases too low.

5. The three main points that every southern dairyman should bear in mind, and which can not be too strongly emphasized, are—

Better cows.

More home-grown feed.

A better product.

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FARMERS' BULLETINS.

The following is a list, by number, of the Farmers' Bulletins available for distribution. The bulletins entitled "Experiment Station Work" give in brief the results of experiments performed by the State experiment stations. Titles of other bulletins are self-explanatory. Bulletins in this list will be sent free to any address in the United States on application to a Senator, Representative, or Delegate in Congress, or to the Secretary of Agriculture, Washington, D. C. Numbers omitted have been discontinued, being superseded by later bulletins.

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 350.

HE DEHORNING OF CATTLE.

BY

RICHARD W. HICKMAN, V. M. D.,
Chief of the Quarantine Division,
Bureau of Animal Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., December 9, 1908.

SIR: I have the honor to transmit herewith a paper on "The Dehorning of Cattle," by Dr. Richard W. Hickman, chief of the Quarantine Division of this Bureau. This article was included in the Twenty-fourth Annual Report of the Bureau, but in order to make it available for distribution in pamphlet form, in response to requests for information on this subject, its publication as a Farmers' Bulletin is recommended.

Respectfully,

A. D. MELVIN,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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THE DEHORNING OF CATTLE.

SIMPLE METHOD OF RESTRAINING THE ANIMALS.

e dehorning of cattle can be very satisfactorily performed with-
ther apparatus or instruments than a good strong clothesline and
an sharp meat saw, or a miter saw with a rigid back. The same
le means for controlling the animal is just as applicable when
rning clippers are to be used as when the horns are to be removed
the saw. The head of the animal is secured to the horizontal rail
ringer which holds the upper ends of the stanchion boards. The
al is put in the stanchion in the usual manner; then one end of a
y clothesline is passed around the upper part of the neck and tied
knot that will not slip, otherwise it will choke the animal. The
end of the rope is now carried between the horns, through the
hion to the front, up and over the horizontal stanchion rail, then
underneath the neck and up and over the top of the stanchion rail
assistant, who should hold it firmly. Now open the stanchion,
ing the animal to withdraw its head; then, keeping the rope tight,
it once around the muzzle, up and over the stanchion rail, and
ugh to the front again to the hands of the assistant, who should
3 or 4 feet in front of the animal and hold the rope firmly, but
ared to release it when told to do so by the operator. The ani-
is now ready for the dehorning operation.

is necessary that the rope be held by an assistant, as in the event
e animal struggling during the operation so as to throw itself off
et, or if there appears to be danger of its choking, the rope may
lackened promptly at the word of the operator and the animal
ly released. This, however, is rarely necessary, for as soon as
head is secured the operator should be ready, standing at the
t shoulder of the animal with his saw, and proceed to saw off first
ight and then the left horn. Figure 1 shows the animal and the
ator in position for the dehorning operation by this method. It
good plan before commencing the real work to experiment upon
imal in the matter of control by tying the head to the stanchion
as described.

the stanchion rail is too wide to permit of properly securing the
r part as well as the upper part of the animal's head, the turn of
rope around the muzzle may be omitted and the last lap of the

rope carried around the stanchion rail to the front and to the of the assistant. Care should be taken that the rope pass eac over the neck of the animal to the stanchion rail between the in such a way that it will not interfere with the work of the sa

WHERE TO CUT THE HORNS.

The horns should be severed from a quarter to a half inch where the skin joins the base of the horn, cutting from the back the front.

If the cut is made too high an irregular, gnarly growth of very apt to follow. It will be seen that the point of union of

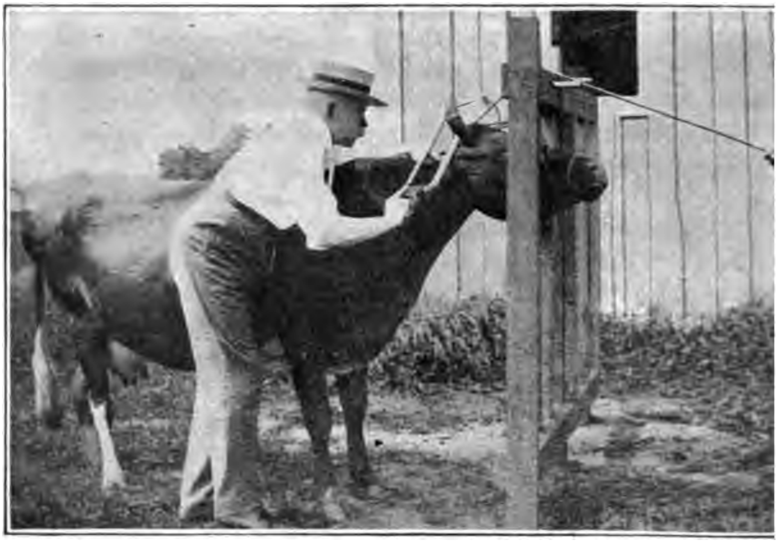

FIG. 1.—Method of tying cow to stanchion rail.

and horn varies in different cattle; hence there can be no rule urement, except as the eye becomes trained to see the point o which the cut should be made. In the beef breeds fully one-ha of skin, all around, is usually taken off with the horn.

Figure 2 illustrates the difference between a proper and an im cutting, and figures 3 and 4 show the appearance of animals' head proper and improper dehorning.

INSTRUMENTS FOR DEHORNING.

In recent years, since dehorning shears or clippers have com use, this means of dehorning is considered by some cattle own be preferable, especially where large numbers of cattle are dehorned. One type of dehorner has a stationary knife blade, its cutting edge shaped like a very wide V, and opposing this another knife of similar shape, moving in a slide, so that the cutting edges cut the horn from all four sides at once, all the edges passing the center at the same time. Another type has a movable knife with one oblique or one curved edge, and the cutting is done in one direction only. The power for cutting with these instruments is supplied by pulling together two long handles, which, in order to transmit a greater force, are generally so constructed that they act through the medium of a series of cogs.

In dehorning with these instruments the opening between the cutting edges should be slipped down over the horn and the knives closed so that their edges set firmly against the horn in such a position that the cut will be made in the right place and in the right direction. The blades should be kept covered with a thick oil or grease. The handles should be drawn together with a quick, firm, strong pull, so that the horn will be completely severed by the first act and without twisting. Care should be taken to keep the blades sharpened on their original bevel.

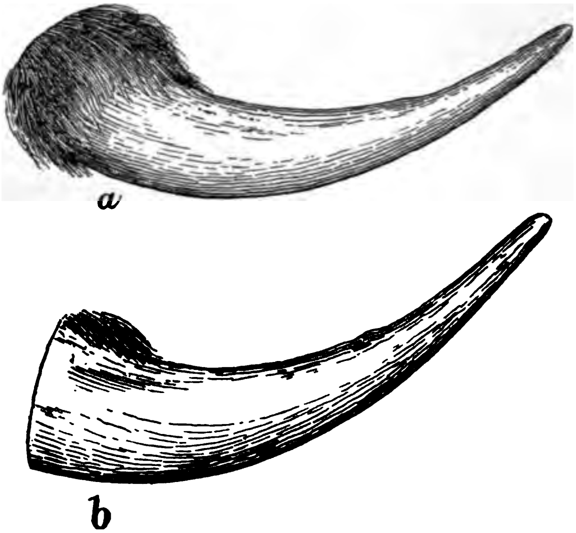

FIG. 2.—Horns showing (*a*) proper and (*b*) improper cutting.

Dehorning instruments can be procured of the manufacturers and of dealers in veterinary instruments.

In dairy districts adjacent to large cities there are men who go about from farm to farm dehorning animals, charging for their services in some instances as little as 5 cents per horn or 10 cents per animal.

There was published in the report of the New Zealand department of agriculture for 1904 a description of the operation of dehorning cattle by the government veterinarian at New Plymouth, in which it was shown that a cage had been used for the restraint of the animals during the operation, closely resembling the box used for hoisting horses out of ships, this cage being hauled on a wagon from farm to farm as needed. In discussing the various means for the removal of the horns the report was very favorable to the use of the saw in dehorning full-grown cattle. It was stated that in the dehorning of over 10,000 cows with the saw there were no deaths due to the operation, while in cows dehorned by shears there was trouble afterwards in healing of the wounds, due, no doubt, to the crushing, fracturing action which this instrument has upon old horns, where ossification of the cores is advanced. Because of this condition it was recommended that for mature animals a bone saw be used.

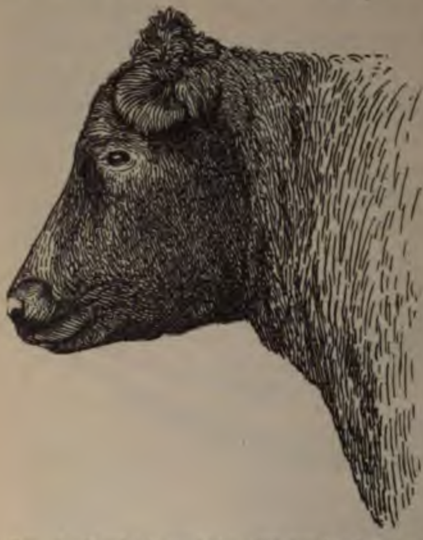

Fig. 3.—Head of steer showing result of proper dehorning.

TREATMENT AFTER DEHORNING.

It is not usual to apply any preparation after the operation of dehorning to prevent bleeding, as the loss of blood is not sufficient, as a rule, to be of consequence. Care should be taken, however, to prevent substances from getting into the openings left after the horns are removed. The horn cores are elongations of the frontal bones of the skull, and are hollow. They communicate with the frontal sinuses, or air spaces, of the head; therefore foreign substances or fragments of horn which act as an irritant in these cavities are apt to set up an inflammation, resulting in the formation of pus or an abscess, which may prove quite serious. This trouble is of infrequent occurrence, but would appear more liable to happen when the dehorning instruments are used, on account of their tendency tó crush, especially in the case of old animals, whereas the saw cuts clean. If proper care is taken, however, such an occurrence following dehorning may in almost every instance be avoided.

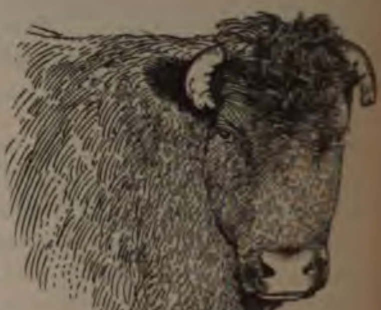

Fig. 4.—Head of steer showing results of improper dehorning.

Occasionally animals after being dehorned and turned out of the stable will rub their heads against a dirt or gravel bank or the rough bark of a tree, and foreign material may thus get into the cavities, though usually the soreness of the parts is sufficient to prevent this

If the animals are dehorned in warm weather, it is well to apply ome pine tar with a view to keeping flies from the wounds. Some operators do this in nearly all cases, thinking that it facilitates healing. The dehorning operation should always, when possible, be performed n cool weather, and upon animals which have at least attained the age of two years.

IS DEHORNING CRUEL?

Inquiries are frequently received as to whether the operation of dehorning is very painful, and whether it may not be classed as cruelty to animals. Those who have had an extensive experience in dehorning appear to agree that the pain induced by the operation has been greatly overestimated, as careful observation has shown that shrinkage in the yield of milk as well as of butterfat following the dehorning of cows is very temporary and insignificant. On the other hand, the worry, pain, and cruelty often inflicted by cattle upon their mates before being deprived of their horns is much more to be considered, and not infrequently results in the death of a valuable animal. A neighbor on an adjoining farm to that owned by the writer a few years ago lost two good milch cows in one winter through their being disemboweled by the horns of barnyard mates while out for exercise. He dehorned his entire herd almost immediately afterwards. The increased safety of the animals much more than compensates for any loss of beauty resulting from the removal of horns.

DEHORNING ON THE RANGE.

While the cattle ranchman of the West seems to be equal to every requirement and emergency of his vocation, and is probably informed with regard to the dehorning of his stock, this article would be incomplete without a description of the dehorning operation as practiced in that part of the country.

In the range country of the West dehorning has been extensively practiced for a number of years, and various methods have been used in restraining the animals, as well as in removing their horns. In some instances the methods used are extremely crude, consisting in simply roping and throwing the animal and cutting off the horns with an ax. Most frequently, however, no matter what may be the means of control, either the saw or the dehorning shears are used. As a general thing the corral and chute which form a part of the equipment of every well-appointed cattle ranch are used for this purpose. Dehorning with an ax should never be attempted, as, no matter how keen the edge of the ax or how true the aim of the axman, he is working on a living animal, and only a slight movement of the head would result in a deviation of the stroke, and would thus be liable to cause, if nothing more serious, the infliction of unnecessary pain and sufferi to the animal.

It is the usual custom in the West to gather the cattle to be d horned in a corral, either during the early spring, before the f season begins, or in the fall, after the fly season has passed. At o side of this corral is a gate opening into another smaller inclosu which is known as the chute pen. The sides of this converge to form an entrance into a narrow chute, which is usually made long enough for about three cattle, though but one is permitted to enter the working end of the chute at a time, the others being kept back by cros bars. At the front end of this chute is what is known as a squeezer,

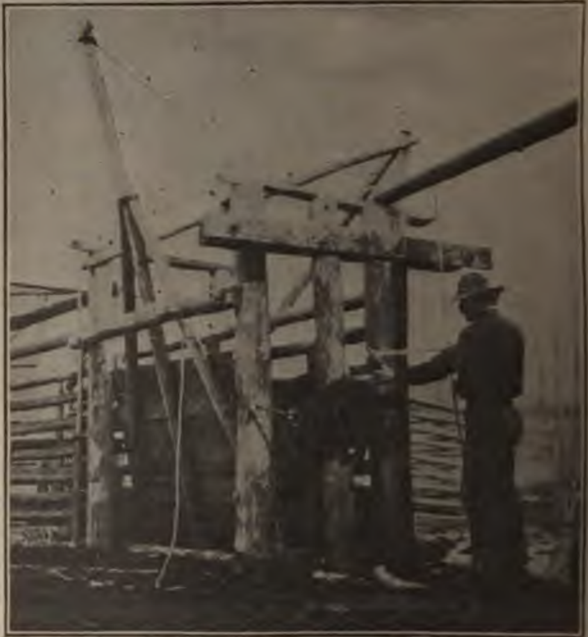

FIG. 5.—Dehorning a steer held in a "squeezer" connected with corral.

the formation of which is best understood by a reference to the illustration (fig. 5). After the animal enters the squeezer the squee gate is pressed close against its side to prevent lateral movement, th stanchion is closed on the neck, and the head is turned and secured to the post by means of a nose clamp and lead rope, first at one side of the chute and then the other, as required for the removal of the horns.

In the construction of these chutes it is usual to have on the side opposite the squeeze gate a movable plank which can be taken ou to expose the side of the animal for branding. In the entire co struction of such a corral and chute it is best not to economize lumber or bolts, as it should be strong and durable, so that the animal may be controlled without danger to itself or to the operator.

Another method of restraint is to throw the animal and hold it
etched flat on the ground by means of a rope around its neck held
a man on horseback with a turn around the saddle pommel, a
ond rope being around the hind feet, similarly held by another man
horseback. In the absence of horses these ropes can be secured
taking a turn around a post. After the animal is thus secured an
istant grasps the nose and upper horn, turning the head so that
lower horn can be removed first. This obviates the danger of
cturing the lower horn, and allows the blood to flow directly on
ground and the head to be held flat for the removal of the upper
n. As shown in the illustration (fig. 6) the dehorning shears are
quently used, but there seems to be a tendency in some localities
ard giving preference to the saw.

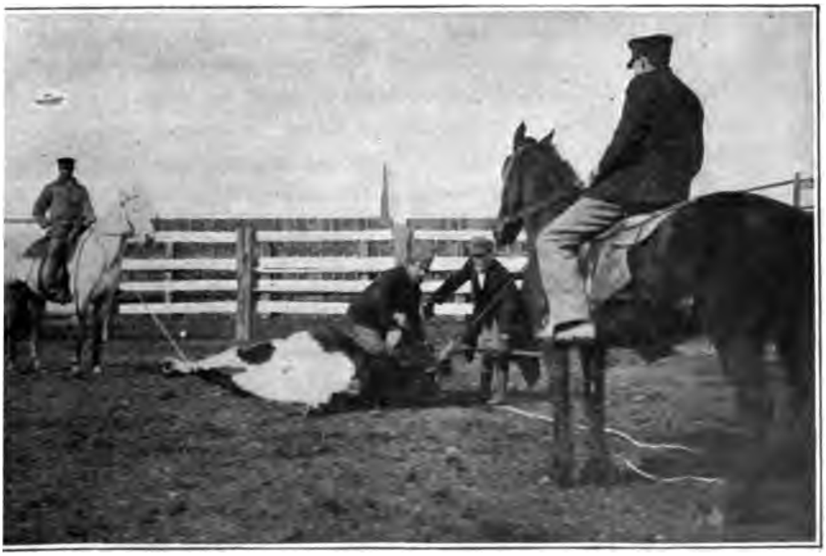

FIG. 6.—Dehorning an animal on the range.

Many ranchmen apply preparations of pine tar and alcohol, or pine
and turpentine, after dehorning, to lessen the bleeding and keep
flies away.

TO PREVENT HORNS GROWING ON YOUNG CALVES.

When circumstances are favorable, as in the case of farmers who
ild up their herds by raising the progeny, the horns may be pre-
nted from growing by a simple and practically painless method,
d the custom of preventing the growth of the horns is becoming
ore popular and more generally practiced under all conditions except
the case of calves dropped on the open range. The calf should be
eated not later than one week after its birth, preferably when it is

from three to five days old. The agent to be used may be either caustic soda or caustic potash, both of which may be procured in the drug stores in the form of sticks about the thickness of an ordinary lead pencil and 5 inches long. These caustics must be handled with care, as they dissolve the cuticle and may make the hands or fingers sore. The preparation of the calf consists in first clipping the hair from the parts, washing clean with soap and warm water, and thoroughly drying with a cloth or towel. The stick of caustic should be wrapped in a piece of paper to protect the hands and fingers leaving one end of the stick uncovered.

Moisten the uncovered end slightly and rub it on the horn button or little points which may be felt on the calf's head, first on one and then the other, alternately, two or three times on each, allowing the caustic to dry after each application. Be very careful to apply the caustic to the horn button only. If it is brought in contact with the surrounding skin it will cause pain. Be very careful also not to have too much moisture on the stick of caustic, as it will remove the skin if allowed to run down over the face. After treatment, keep the calf protected from rain, as water on the head after the application of caustic will cause it to run down over the face. This must be carefully avoided.

Either caustic soda or caustic potash alone, without the admixture of other substances, answers the purpose satisfactorily. Some years ago, however, certain preparations or "dehorning compounds," composed largely of one or the other of these caustics, were generally used, and as inquiries are still occasionally received concerning such preparations, the following formula is given: Combine in an emulsion 50 per cent of caustic soda, 25 per cent of kerosene, and 25 per cent of water. The caustic soda is dissolved in the water and heated to the boiling point, then removed from the fire, and the kerosene added gradually, while the mixture is vigorously stirred. This emulsion is applied in very much the same manner as the stick caustic, except that it is necessary to employ a short, stiff brush. Sometimes a meat skewer is used, the large end being mashed to form a stubby brush. Two or three applications should be made to each horn button, as in the case of the stick caustic, with intervals to allow it to dry.

In the very young calf the horn button, or point that will ultimately develop into a horn, has scarcely any attachment to the skull, and may be felt as a small button embedded in the skin. In this early stage it may be easily removed with a sharp knife or a pair of curved scissors; but even then caustics should be applied to kill any remaining cells belonging to this germ point; otherwise there may be some subsequent irregular horn growth, which is more or less of a disfigurement

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U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 351.

E TUBERCULIN TEST OF CATTLE FOR TUBERCULOSIS.

BY

JOHN R. MOHLER, A. M., V. M. D.,
Chief of the Pathological Division, Bureau of Animal Industry.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., December 30, 1

SIR: I have the honor to transmit herewith a paper on The T culin Test of Cattle for Tuberculosis, by Dr. John R. Mohler, (of the Pathological Division of this Bureau.

Tuberculosis of cattle, although not so prevalent in the U States as in some other countries, nevertheless exists here t alarming extent, especially in some States where no steps have taken for its suppression. It is estimated that on an average not than 1 per cent of the beef cattle and 10 per cent of the dairy ca in the country are affected with this disease, and in some locali the percentages are very much higher. The financial loss from tub culosis in live stock is not less than $14,000,000 annually.

As the first step in any measure for eradication, either by pub authorities or by private owners, it is necessary that there sho be some accurate and reliable method of diagnosis. In the gr majority of cases it is impossible to detect the disease in the liv animal by ordinary physical examination. The tuberculin test. pointed out by Doctor Mohler, affords the most reliable known meth for detecting tuberculosis in cattle, records having proved its accura in over 97 per cent of cases, and it has the additional advanta of being harmless.

It is important, however, that a reliable tuberculin be used. experiments by this Bureau have shown that some of the tubercul on the market is impotent and worthless. It seems likely that som of the dissatisfaction occasionally experienced with the tubercul test is due to this fact. The Bureau of Animal Industry prepar a trustworthy tuberculin and furnishes it free of charge to healt officers and other public authorities under certain conditions f official use. The Bureau can not, however, supply tuberculin on an terms for private use.

The accompanying paper was included in the Twenty-fourth Annu Report of this Bureau, but in order to make it available for wide di tribution in pamphlet form I respectfully recommend its publicati also in the Farmers' Bulletin series.

Respectfully,

A. D. MELVIN,
Chief of Bureau

HON. JAMES WILSON,
Secretary of Agriculture.

HE TUBERCULIN TEST OF CATTLE FOR TUBERCULOSIS.

THE DIAGNOSIS OF TUBERCULOSIS.

The symptoms of tuberculosis in cattle are not sufficiently promient, except in advanced stages or when superficially located, to nable one to diagnose this disease by the ordinary methods of hysical examination. And the cattle may, without showing any linical symptoms, be in such a stage of tuberculosis as to render them apable of spreading disease. Indeed, an animal may be fat and leek, eat and milk well, have a bright, glossy coat, and be apparently n the pink of condition, and still be passing tubercle bacilli through he feces or by an occasional cough, and thus endanger all the healthy attle in the herd. Consequently such adventitious aids to diagnosis s animal inoculation, biological test, serum agglutination reaction, nd the tuberculin test are made use of in arriving at a definite pinion relative to the presence or absence of this disease. The value f all but the last of these is discounted by the technique required nd by their impracticability, while the tuberculin test is most satisctory and is the best diagnostic agent known for the disease.

THE ORIGIN OF THE TUBERCULIN TEST.

Tuberculin was invented by Koch in 1890, and was first used exrimentally in treating tuberculosis in man. In these cases it was served that its injection was followed by a rise of temperature, hich led veterinarians to apply tuberculin to suspected animals to e if a similar reaction resulted. Numerous experiments showed this be the case, and since 1891 the use of tuberculin as a diagnostic ent for tuberculosis of cattle has been almost universally adopted all parts of the civilized world. No one thinks of accepting berculin as an absolutely infallible agent, but it is immeasurably re dependable than any other method that has ever been used.

THE NATURE AND APPLICATION OF TUBERCULIN.

Tuberculin is the sterilized and filtered glycerin extract of cultures tubercle bacilli. It contains the cooked products of the growth these bacilli, but not the bacilli themselves. Consequently, when his substance is injected under the skin of an animal it is absolutely

unable to produce the disease, cause abortion, or otherwise
animal. In case the injected animal is normal there is
effect upon the system than would be expected from the in
sterile water. However, if the animal is tuberculous, a de
of temperature will follow the use of tuberculin.

In practice the tuberculin test is applied by first taking a
number of temperatures, usually three, at intervals of two
ascertain the normal variation of temperature of the anin
tested. The dose of tuberculin (which should always be spe
the label) is then injected hypodermically between 8 and 10
the day of taking the preliminary temperatures.[a] On the
day the "after" temperatures are recorded every two hour
ning at 6 a. m. and continuing until twenty hours follow
injection.

THE VALUE AND RELIABILITY OF THE TUBERCULI

As a result of this method an accurate diagnosis may be esta
in over 97 per cent of the cases tested.[b] The relatively few
in diagnosis are included among two classes of cattle. The fir
contains those that are tuberculous but which do not react
because of the slight effect of an ordinary-sized dose of tuberc
an advanced case of the disease with so much natural tub
already in the system, or on account of a previous test with tub
which produces a tolerance to this material lasting for abo
weeks. The second class includes those that are not tuberculo

---

[a] Great interest has been manifested recently in the cuti tuberculin test
Pirquet and the ophthalmo tuberculin test of Wolff-Eisner and Calmette.
names imply, these tests consist in the application of the tuberculin to the e
to the scarified skin, respectively, of the animal to be tested. The very fa
results which were reported from the application of both of these methods ex
great deal of interest among investigators, and soon numerous results of the exper
were published, which, however, were not uniformly favorable for either of th
The best results were apparently obtained from the ophthalmo reaction
changes in the eye resulting from a marked reaction are characteristic; intoler
light and an increased secretion of tears are the first indications, which may
lowed by more severe symptoms, as marked congestion of the conjunctiva, a
film-like exudate over the bulbar conjunctiva, and a grayish yellow discharge fr
eye, which, running down the face, forms crusts. The test is applied to only o
and in the reaction the other or control eye should remain normal.

Thus far the ophthalmo and cuti tuberculin tests can not be recommen
general practice as methods of diagnosing tuberculosis of bovines, and they will
further work and perfection before they should pass from the experimental st
be adopted in place of the present reliable subcutaneous application.

[b] Reports of tuberculin tests made in the fifteen years from 1893 to 1908 by
State, and other officers with tuberculin prepared by the Bureau of Animal
show that out of 24,784 reacting cattle slaughtered, lesions of tuberculosis we
in 24,387, a percentage of 98.39.

which show an elevation of temperature as a result of (*a*) advanced pregnancy; (*b*) the excitement of œstrum; (*c*) concurrent diseases, as inflammation of the lungs, intestines, uterus, udder, or other parts, abortion, retention of afterbirth, indigestion, etc.; (*d*) inclosure in a hot, stuffy stable, especially in summer, or exposure to cold drafts or ains; or (*e*) any change in the method of feeding, watering, or stabling of the animal during the test.

Notwithstanding all these possibilities of error, the results of thousands of tests show that in less than 3 per cent of the cases tested do these failures actually occur. In the first class the chances of error are decidedly reduced by the skilled veterinarian by making careful physical examination and diagnosing these advanced cases, and by he injection of double or triple doses into all recently tested cattle, with the taking of the after temperatures beginning two hours following the injection and continuing hourly for twenty hours. In he second class errors are avoided by eliminating those cases from the test that are nearing parturition or are in heat, or show evidence of the previously mentioned diseases, or exhibit temperatures sufficiently high to make them unreliable for use as normal. Then, in reading after temperatures it is advisable not to recognize as a reaction an elevation of temperature less than 2° F., or one which at the same time does not go above 103.8° F., and the temperature reaction must likewise have the characteristic rainbow curve. (Those cases which approximate but do not reach this standard should be considered as suspicious and held for a retest six weeks later.) In addition, a satisfactory tuberculin must be used, also an accurate thermometer and a reliable syringe in order that a sufficient dose of tuberculin may be given. Finally, the number of apparent errors of the tuberculin test will be greatly diminished if a careful post-mortem examination is made, giving especial attention to the lymph glands.

This low percentage of failures being the case, cattle owners should welcome the tuberculin test not only for their own interest but for the welfare of the public as well. Where this method of diagnosing the disease has been adopted tuberculosis is gradually being eradicated, while it is spreading rapidly and becoming widely disseminated those districts where the tuberculin test has not been employed. Without its use the disease can not be controlled and the cattle owner confronted with serious and continuous losses; with its use the disease can be eradicated from the herd, a clean herd established, and the danger of its spread to man removed. Tuberculin may, therefore, considered a most beneficial discovery for the stock raiser. Strange say, many of these men have been incredulous, antagonistic, or prejudiced against the tuberculin test by misinterpreting published statements, by incorrect, unsubstantiated, or exaggerated reports and by alleged injurious effects to healthy cattle.

Law[a] has clearly stated the question when he says:

> Many stock owners still entertain an ignorant and unwarranted dread of the tuberculin test. It is true that when recklessly used by ignorant and careless people it may be made a root of evil, yet as employed by the intelligent and careful expert it is not only perfectly safe, but it is the only known means of ascertaining approximately the actual number affected in a given herd. In most infected herds, living under what are in other respects good hygienic conditions, two-thirds or three-fourths are not to be detected without its aid, so that in clearing a herd from tuberculosis, and placing both herd and products above suspicion, the test becomes essential.
>
> * * * * * * *
>
> In skilled hands the tuberculin test will show at least nine-tenths of all cases of tuberculosis when other methods of diagnosis will not detect one-tenth.

It is perfectly natural that there should be objection to its use among those who are not acquainted with its method of preparation or its properties; but it is difficult to explain the antagonism of farmers who are familiar with the facts connected with the manufacture and use of tuberculin. Probably the most popular objection to tuberculin is that it is too searching, since it discovers cases in which the lesions are small and obscure. While this fact is admitted, it should also be borne in mind that such a small lesion to-day may break down and become widely disseminated in a relatively short period. Therefore any cow affected with tuberculosis, even to a slight degree, must be considered as probably dangerous not only to the other animals in the herd but also to the consumer of her products.

THE HARMLESSNESS OF TUBERCULIN.

Furthermore, tuberculin must be considered as harmless for healthy animals in view of the results revealed by numerous tests covering vast numbers of animals. And it has also been clearly demonstrated that tuberculin interferes in no way with the milking function in healthy cattle; neither in the quantity of milk nor in butterfat value has any variation been detected.

Nocard and Leclainche[b] state:

> Direct experiments and observations collected by thousands show that the tuberculin injections have no unfavorable effect. With healthy animals the system is indifferent to the inoculation; with tuberculous animals it causes only slight changes, which are not at all serious.

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[a] Text Book of Veterinary Medicine, vol. 4, pp. 458, 465. Ithaca, N. Y., 19[illegible]

[b] Les Maladies Microbiennes des Animaux, vol. 2, p. 85. Paris, 1903.

)ISPOSAL OF AND INDEMNITY FOR REACTING ANIMALS.

:ost of the objections to tuberculin would probably be removed if e method of compensation for the reacting animals could be de- d. Thus, in Pennsylvania, where tuberculosis is being eradicated ı more success than in any other State, and where there are ılly three times as many voluntary requests on file for the appli- on of the test as can be made, all reacting animals are paid for by State. As the suppression of tuberculosis is a public health ısure, it would appear perfectly logical for the State governments eimburse cattle owners appropriately for the animals condemned slaughtered. Provision could be made to pay 70 per cent of the raised value of the condemned animals, not to exceed $30 a head :ommon stock or $60 for registered stock. Such legislation should include a requirement for the testing of all dairy and breeding le coming into the State.

ll tuberculous animals should be slaughtered in abattoirs having petent inspection, and the money obtained from those slight and lized cases which are inspected and passed for food and from the ı and offal of those carcasses condemned as unfit for food should be lied as part payment on the indemnity for their respective owners. payment of indemnity for tuberculous animals is a good busi- policy and would do more toward making the tuberculin test pop- with cattle owners than any other possible action. And as a ollary of the latter, more testing would be performed and more ·rculous cattle would be discovered at the start, but the gradual ɔression of the disease would soon be manifest, as has been noted ·nnsylvania and Denmark. Furthermore, as Stiles has mentioned, berculosis can be eradicated from dairy herds with but slight loss he owner, the increase in the price of milk would naturally be ɔited, and the children of poor families would consequently be ·ss danger of having this very important article of their diet eased.

CONCLUSIONS REGARDING THE TUBERCULIN TEST.

s a result of the careful study of the tuberculin test, Salmon[a] vs the following conclusions:

That the tuberculin test is a wonderfully accurate method of determining :her an animal is affected with tuberculosis.

That by the use of tuberculin the animals diseased with tuberculosis may be cted and removed from the herd, thereby eradicating the disease.

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[a] Yearbook of the United States Department of Agriculture, 1901, p. 592.

3. That tuberculin has no injurious effect upon healthy cattle

4. That the comparatively small number of cattle which have a in health, or fallen off in condition after the tuberculin test were eith fore the test was made or were affected by some cause other than th

SUMMARY OF DIRECTIONS FOR MAKING THE TUBERCU

1. Stable cattle under usual conditions and among usual ings, feeding and watering in the customary manner

2. Make a physical examination of each animal, and giv one some designation by which the animal will be known th the test.

3. Take each animal's temperature at least three times three hour intervals on the day of injection; for instance and 8 p. m.

4. At 8 or 10 p. m. inject a dose of tuberculin under the s region of the shoulder, using a sterile hypodermic syringe infecting the skin at the seat of injection with a 5 per cent of carbolic acid or a similar antiseptic solution.

5. Tuberculin is not always concentrated to the same deg therefore the dose, which should always appear on the lab considerably. The dose of imported tuberculin is 0.25 c. c adult cow, and before injection is diluted with sterile water The tuberculin made by the Bureau of Animal Industry is so that it will not be necessary to dilute it, and the dose is 2 an adult animal. Yearlings and 2-year-olds, according to si receive from 1 to 1½ c. c., while bulls and very large ani receive 3 c. c.

6. At 6 a. m. on the day following the injection of tuberc mence taking temperatures, and continue every two or th until the twentieth hour after injection, at which time if th tendency for the temperature to rise the test may cease.

7. A rise of 2° F. or more above the maximum tempera served on the previous day, providing the temperature after in exceeds 103.8° F., should be regarded as an indication of tub Those cases which approximate but do not reach this standar be considered as suspicious and held for a retest six weeks giving double the original dose.

Issued March 20, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 352.

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THE NEVADA MOUSE PLAGUE OF 1907-8.

BY

STANLEY E. PIPER,
Assistant, Biological Survey.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Biological Survey,
Washington, D. C., January 12, 1909.

Sir: I have the honor to transmit herewith, and to recommend for publication as a Farmers' Bulletin, a report on the Nevada Mouse Plague of 1907–8, by S. E. Piper, an assistant in the Biological Survey.

The report is important from three points of view: (1) It is the first account we have ever had of a fully developed mouse plague in America; (2) it shows that such plagues may be successfully combated; and (3) it emphasizes the necessity for protecting our native hawks and owls and the smaller predatory mammals in order to prevent the recurrence of such plagues in future.

Respectfully,

C. Hart Merriam,
Chief, Biological Survey.

Hon. James Wilson,
Secretary of Agriculture.

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FIG. 1. Alfalfa plant killed by field mice..................
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HE NEVADA MOUSE PLAGUE OF 1907-8.

INTRODUCTION.

This bulletin gives an account of the recent mouse plague in Hum-
dt Valley, Nevada. Its object is to acquaint farmers with the
gers from field mice and to describe the best methods of destroy-
and controlling the animals. Though referring particularly to
Nevada outbreak, the recommendations apply to similar species
ther parts of the United States.

THE MOUSE PLAGUE IN HUMBOLDT VALLEY.

HISTORY OF THE OUTBREAK.

amage by field mice attracted the attention of the ranchmen in
lower part of Humboldt Valley early in the spring of 1906 and
me severe during the following summer.[a] In the fall and winter
906–7, damage had increased until fields here and there in the
ey were seriously injured. Extensive ravages first occurred above
about Lovelocks. In May, 1907, fields on the Rodgers ranch,
iles below Lovelocks, were invaded from the lands farther up the
ley, the progress of the mice being plainly marked, as the fields
ve the Rodgers ranch suffered first. The movement of this great
dy of mice, it should be noted, was a gradual, scattering progres-
n, first by a few and later by increasing numbers, until the greater
rt had moved to fresh fields. Numbers, however, finding conditions
proved, remained as stragglers in the fields deserted by the main
dy.

By October, 1907, a large part of the cultivated lands in this dis-
ct had been overrun by vast numbers of mice. The yield of hay
d been reduced by one-third; potatoes and root crops were largely
troyed; many alfalfa fields were ruined by the mice eating the
ts of the plants; and the complete destruction of this, the chief
p in the valley, was threatened.

The height of abundance was reached in November, when it was
mated that on many large ranches there were from 8,000 to 12,000

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[a] Reported by J. S. Cotton, Sept., 1906.

mice to each acre.[a] The fields were riddled by their holes, which were scarcely a step apart, and over large areas averaged 150 to 175 to the square rod. Ditch embankments were honeycombed, and the scene was one of devastation. Serious losses in hay and root crops during the summer proved but a slight forerunner of the damage which began in the fall with the disappearance of green food. Burrowing down about the plants, and extending their underground runs from root to root, they either killed or seriously injured the alfalfa (fig. 1). By November they had destroyed so large a percentage of the plants that many fields were plowed up as hopelessly ruined (see fig. 2). They attacked also the roots of trees, seriously injuring or quite destroying orchards. They killed most of the young shade trees planted along ditches, and so completely girdled large Lombardy and silver poplars (fig. 3) that in some cases they caused the death of even such hardy trees.

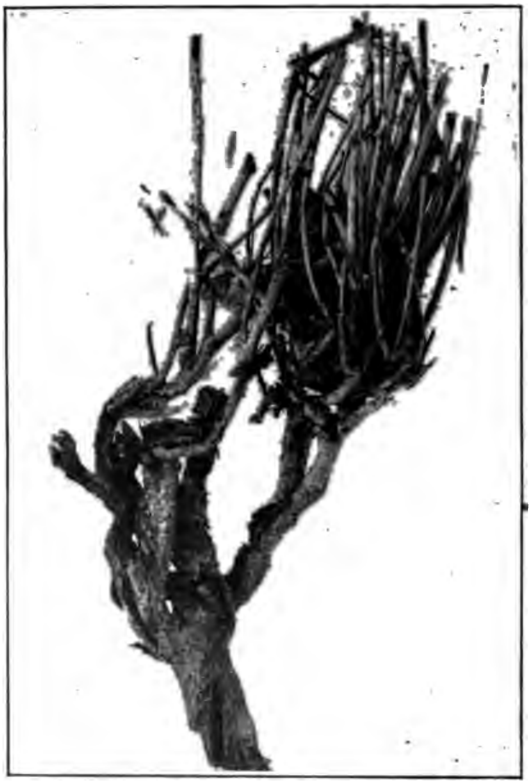

FIG. 1.—Alfalfa plant killed by field mice.

By January, 1908, in fields where the mice had existed by thousands the previous summer and fall, comparatively few, possibly 200 to 500 to each acre, remained. The border of the destroyed district was about 6 miles below Lovelocks, and the mice were gradually moving further down the valley. In the area below this, mice were somewhat in excess of normal numbers and in several centers of abundance had seriously injured fields. Even where most abundant, along the lower border of the affected area, they did not exceed 1,500 to the acre. In the winter they attacked every available food supply. Small willows and even greasewood bushes about the borders of fields were stripped of all the bark within reach, and horse and cattle droppings were gnawed to pieces for the food they contained. Alfalfa roots, however, were the food supply on which the mice were chiefly dependent.

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[a] Reported by Vernon Bailey, Nov., 1907.

EFFORTS OF RANCHMEN TO COMBAT THE PLAGUE.

In Nevada, the great majority of ranchmen knew neither what to expect from such great numbers of mice nor how to check them. It must be said, however, that no previous examples of successfully controlling such plagues exist; usually they have run their courses until brought to an end by natural agencies. Hence it is not surprising that in Humboldt Valley no concerted or systematic efforts to suppress the plague in its earlier stages were undertaken, but after the mice swarmed in thousands over the fields many attempts were made to destroy them by distributing wheat poisoned with phosphorus. These, however, were spasmodic and generally proved futile, as the fields experimented on were quickly reinvaded from adjoining lands. While a few fields favorably located were saved by early poisoning, the results of such unsystematic efforts amounted to practically nothing in overcoming or even materially checking the plague.

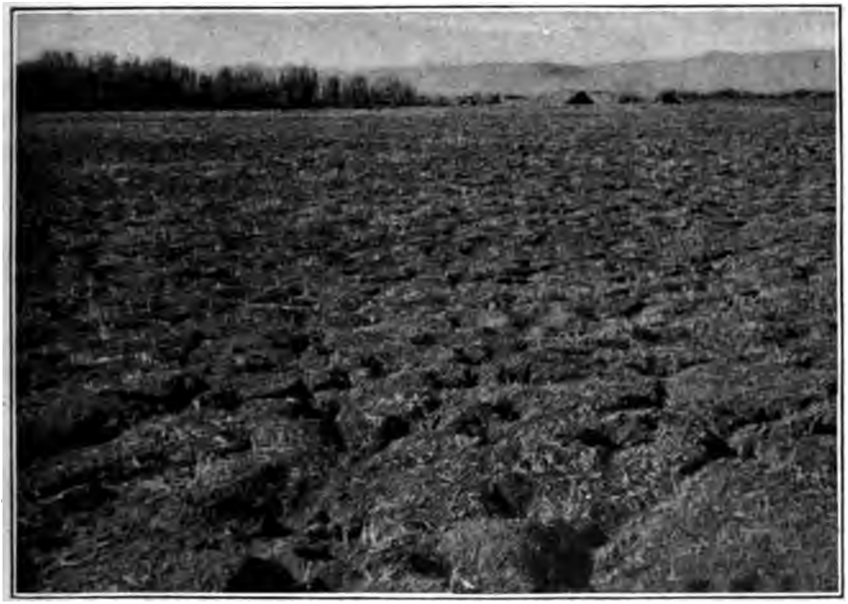

FIG. 2.—Alfalfa field ruined by mice, showing general condition of fields in Humboldt Valley in January, 1907.

The preparation in general use by ranchmen consisted of wheat treated with a strong solution of yellow phosphorus in carbon bisulphid, a cheap and effective poison for field mice, but inflammable, explosive, and dangerous to birds. As a result of its extensive employment in the valley, California quail, an introduced species, were decimated, and magpies, crows, meadow larks, and smaller seed-eating birds suffered extremely. On one occasion 67 horned larks were found dead on about 4 acres a few hours after the poisoned grain had been distributed. Fortunately hawks, owls, gulls, and ravens were not affected, but many skunks and domestic cats were killed as the result of eating mice dying or dead of phosphorus. Several accidents occurred in handling the solution, and cases of fatal poisoning of live stock were frequent.

Several attempts by ranchmen to induce contagious diseases among the mice by means of advertised bacterial preparations failed.

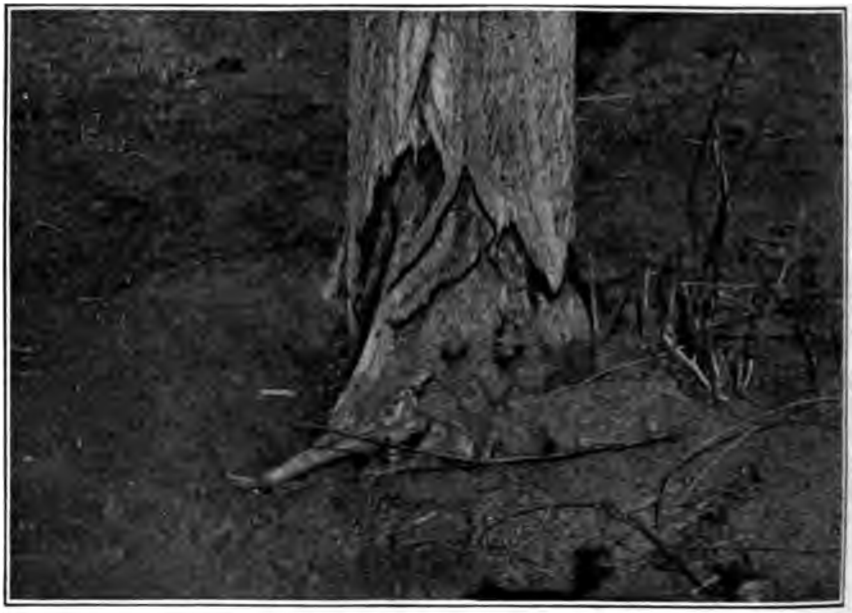

FIG. 3.—Lombardy poplar girdled and killed by field mice.

HOW THE OUTBREAK WAS FINALLY CONTROLLED.

Chiefly through the cooperation of Mr. George S. Webb, manager of the large Rodgers ranch, systematic experiments to destroy the pests, undertaken early in January by the Biological Survey, yielded results demonstrating that such mouse plagues can be controlled, and the greater part of the losses prevented. The experiments proved that mice could be effectively destroyed in winter by alfalfa hay poisoned with strychnia sulphate, and this preparation was generally recommended in the valley. On the Rodgers and Anker ranches a force of 7 to 15 men was employed to distribute the poison in the fields, with most satisfactory results, and without the dangers incident to [illegible] use of phosphorus and grain.

During this winter season, when the mice were not breeding, large numbers of predatory birds and mammals had steadily depleted their numbers. Mortality, believed to be due to disease, perhaps engendered by the straitened food supply and the severe winter weather, had been everywhere evident. Dead and dying mice attracted general notice, and in opening burrows where no poison had been distributed dead mice were frequently found in their nests.

By March 15, poisoning, supplemented by these natural agencies, had destroyed the mice on several thousands of acres where they were most abundant, and the plague was broken before the remaining alfalfa fields had been overrun. In scattered centers mice continued in destructive numbers until May, but without regaining to any considerable extent by reproduction, they steadily decreased. Later in the summer they had almost disappeared from the valley.

ESTIMATES OF DAMAGE.

The scourge of mice swept over about four-fifths of the cultivated area in the lower part of Humboldt Valley. Of about 20,000 acres in alfalfa, about 15,000 were so seriously injured as to require plowing and replanting. Over most of this area the alfalfa was replaced by grain crops for the season of 1908, at great expense and loss, since good alfalfa lands pay gross returns of from $60 to $70 per acre, while good grain crops return only $35 or $40 per acre.

The shortage of hay on the Rodgers ranch, where 2,200 acres were in alfalfa, was estimated at 2,000 tons. On Anker's ranch of 650 acres, it was estimated at 600 tons. Other ranches suffered in proportion, and the loss of hay in the valley amounted to not less than $50,000. The following estimates, independently considered, indicate the severity of the depredations. W. C. Pitt, who farms 1,400 acres of alfalfa, estimates his complete loss at $20 per acre, or $28,000. John Font estimates his damage on 1,000 acres at $20,000, and Mr. Anker considers his loss on 650 acres to be $8,000. Mr. Webb, on the Rodgers ranch, figures the complete loss on 2,200 acres, part of which pays considerably short of the best returns, at $30,500.

A careful consideration of the losses in hay, pasturage, root crops, and trees, the expense of restoring alfalfa fields to their former condition, and deducting the value of a grain crop for 1908 shows the average loss to be about $20 per acre.[a] On this basis the damage to the valley amounts to $300,000. Allowing for the saving of a few fields by early poisoning, and for others not entirely destroyed, the loss may have been a little less than $300,000.

Simultaneously with the plague in the lower part of Humboldt Valley mice appeared in enormous numbers farther up the Humboldt

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[a] Figured on the basis of 1,000 acres on **Rodgers ranch.**

River and its tributaries about Winnemucca, Battle Mountain, and in Paradise and Little Humboldt valleys. As the lands infested in those districts were chiefly great natural hay meadows of red top and wild clover, the damage was less severe. However, gardens and isolated alfalfa fields were seriously injured. Later, reports of mice in alarming abundance were received from King River, Quinn River, and Carson and Smith valleys, Nevada; from Weber River Valley, and from Sanpete and Utah counties, Utah; and from Honey Lake Valley, California. In none of these localities was the damage so extensive as in Humboldt Valley, though plagues of like severity were plainly threatened.

A PLAGUE THREATENED IN CARSON VALLEY.

Reports of severe damage by mice in Carson Valley, a hundred miles southwest of Lovelocks, in April, 1908, led to investigations which have an important bearing on the subject. Carson and Humboldt valleys are alike in having large areas in alfalfa bordered by desert lands on which field mice do not live. On a tract of about 2,500 acres near Minden, mice were found to be excessively abundant, and in some fields 10 to 25 per cent of the alfalfa plants had already been destroyed. Several smaller centers were similarly affected, while over the valley generally the mice were somewhat in excess of normal numbers. This was a condition similar to that presented in Humboldt Valley during the spring of 1907, and young of all sizes were abundant. Examination of many females, a large percentage of which were pregnant, showed an average of from 6 to 7 young, while in a number as many as 10 were found. Many females suckling young were found to be again pregnant. This was in marked contrast with the condition in Humboldt Valley, where, at this time, the mice were steadily decreasing without any general reproduction. The mortality among the mice so strongly in evidence during the winter and spring in Humboldt Valley was not found here. In fact, the pests were plainly increasing; while in Humboldt Valley they were steadily diminishing. Reproduction at the rate noted at Minden might and probably would have resulted in a plague by fall.

It can not be too strongly emphasized that at this stage of development mouse plagues can be checked, as was demonstrated by results actually obtained here. Although alfalfa was already well grown, furnishing the mice abundant food, by systematic poisoning they were so effectively reduced in the infested areas as not to be dangerous again during the season—in other words, a plague was averted.

PREVIOUS OUTBREAKS.

This is not the first time that field mice have inflicted serious damage in Humboldt Valley. Accounts by the older ranchmen indicate that a similar scourge occurred from 1889 to 1892. The mice were very abundant during the period from 1899 to 1901, the outbreak approaching in severity the present one, though affecting less of the valley. Between these periods damage of more local nature was frequent. The same species was reported to be extremely abundant and very injurious to crops in Carson Valley in 1892,[a] and several times since it has seriously menaced the valley.

ORIGIN AND PROGRESS OF SUCH PLAGUES.

A few observations on the development of this mouse plague are pertinent, since they bear directly upon the control or prevention of similar irruptions in the future. Always present in Humboldt Valley, these mice attract little attention when in small numbers. Usually they are not uniformly abundant in the district; in fact in many of the fields they may not be present at all. They live in scattered colonies in swampy places; along the borders of sloughs and irrigation ditches; in salt grass patches and in similar damp areas. When in normal numbers a little damage may be noticeable about the borders of fields or along ditches, where plants have been killed during winter and spring. Ordinarily the mice are very prolific, each pair producing 4 to 6 litters of about 6 young each during the long breeding season, which extends from March to November; and probably the young born early in the season breed before fall. Occasionally conditions favor excessive multiplication, and under such circumstances damage soon becomes evident, and in a single season may increase locally to the serious injury of fields. Extending from such centers during the next breeding season, and increasing not only by reproduction but by joining with other colonies, a vast army of mice is formed. Because of overcrowding and the limitation of food, such armies invade adjoining districts, and this progress becomes more rapid with the disappearance of green food in the fall. Through the combination of several such armies, entire districts are overrun.

Mice plagues usually develop within the affected districts. The essential point is this: It takes several seasons to produce a general plague of mice, and damage is noticeable for at least a season before a serious outbreak occurs. Though natural agencies may be depended upon to overcome such abnormal numbers finally; yet, unless active repressive measures are taken, enormous damage to crops will result. Control, easy at first, becomes more and more difficult as the mice increase in numbers, and, after a plague is well established, is very expensive.

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[a] W. W. Price, Zoe. Vol. 4, 1893–4.

THE SPECIES RESPONSIBLE FOR THE PLAGUE.

The mouse which produced the plague in Nevada, locally as "black mouse" (fig. 4), proved to be the Carson field (*Microtus montanus*), one of the numerous species of shor field mice or meadow mice, a group which has caused wid destruction in variou of the world.[a] Thi mouse is rather wide tributed in the vall Utah, Nevada, north California, and easte gon. In nearly all p the United States tailed field mice are the most abundant o mals, and a num species in widely se localities have occas exhibited the same te to excessive increase, i ing that favoring con may produce mouse wherever the mice Even when in small bers they destroy co able clover and alfal injure orchards, nu and root crops.

This is the first re instance of an irrup field mice in North A attaining the proport a plague. The exp indicates the probabi future and even mo astrous outbreaks. extensive reclaimed a the West the abunda and luxurious cove nished by alfalfa fie the miles of irr ditches, which afford these mice suitable homes along their greatly favor their increase, while surrounding desert condition the spread of mice beyond the cultivated areas.

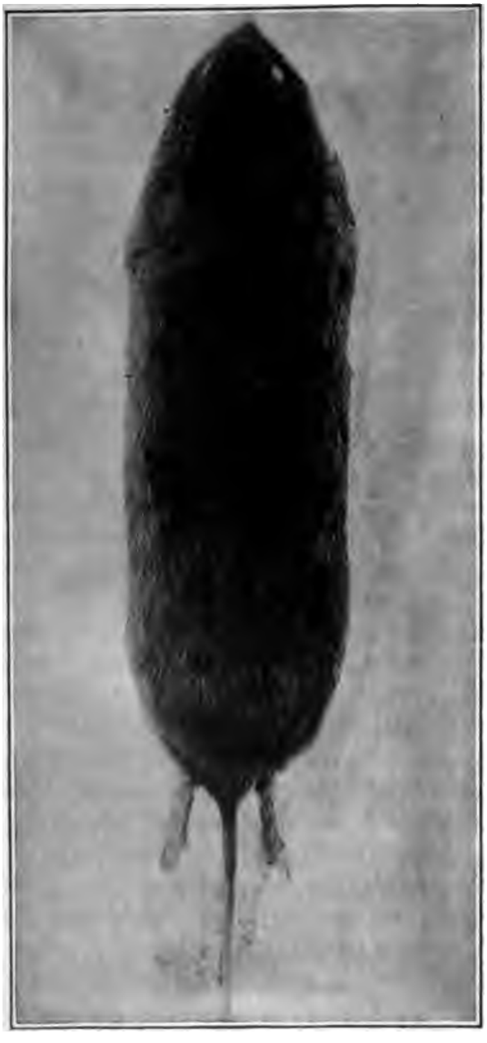

FIG. 4.—The Carson field mouse (*Microtus montanus*).

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[a] For an account of the group see Bulletin 31, Biological Survey.

REPRESSIVE MEASURES.

POISONS.

ithout doubt poisoning is the best method at present known ealing with field mice on an extensive scale. Besides effective- poisons should possess the additional advantage of small cost he least possible danger to man, to domestic stock, and to val- wild birds and animals. Comparative tests of a large number isons, including strychnine, phosphorus, lead acetate, mercuric ide, arsenic and its compounds, proved strychnia sulphate by he best and most practicable. Used in proper proportions it is ore costly than arsenic, lead acetate, or mercuric chloride. More- it is much more readily eaten than are these poisons, which r some of the best baits unattractive to mice. Used on wheat onsiderably more expensive than phosphorus, but possesses many ntages; however, it may be used on mediums which make it the est poison practicable.

osphorus.—Yellow phosphorus is exceedingly dangerous to handle sometimes causes disastrous fires. Its solution in carbon bisul- is highly explosive, while wheat grains poisoned with it are readily by many birds. Thus the wheat poisoned with this ion, used by many Nevada ranchmen, was as dangerous a poison epare and to use as could well be devised. The preparation was e form of a rapidly diffusing liquid, of which six ounces were ient to poison a sack of wheat.

ny ranchmen adopted the method of broadcasting the poisoned t over their fields, either by means of broadcast seeders or and. About 40 pounds of grain were required for each acre. gh many mice were killed, this method falls far short of yield- he best results. It is not much cheaper than other methods, as roportion of poisoned grain wasted makes up for the lessened . Furthermore, its use is attended with the greatest possible er to birds.

much better method of distributing this poisoned grain is to about half a teaspoonful into each mouse burrow. Field mice their movements to their own systems of trails and burrows, t is essential to place a fatal dose of poison within reach of each e. About 90 per cent of the mice were killed by this method, n the worst-infested fields a man could cover only three or four a day, and the average cost, including labor, was from 80 to 90 per acre.

ychnine.—Strychnine is commonly on the market in two forms. he purpose of poisoning field mice, care should be taken to pro- strychnia sulphate, as this is much more readily soluble in

water than ordinary strychnine crystals. Even in powd
the sulphate is required. It fluctuates considerably in
usually can be obtained wholesale at about 75 cents an ou

Poisons should always be prepared at a distance from
where stock and poultry are not endangered. To avoid
persons strychnine and the vessels in which it is used should
be carefully handled and safely stored away when not in u
nary 5-gallon oil cans, for which covers and wire handles
provided, make excellent utensils. A firehole about 2 feet l
foot wide, over which two iron rods are placed to support
makes a fireplace where the solutions can be quickly prepar
vanized iron wash tubs are suitable for mixing the material
be used. For preparing poisoned alfalfa on the large scal
necessary, a large metal receptacle which will permit the m
30 pounds of hay at once is required. One or two oil can
into gallon measures, a sprinkling can, and several large stru
complete a handy outfit for preparing poisons.

BAITS FOR THE ADMINISTRATION OF POISON.

Tests with various baits or vehicles for poison show that t
sess distinct advantages. These are alfalfa hay, green alf
crushed wheat.

Alfalfa hay.—Alfalfa hay was found to be the best v
medium for carrying the poison in winter. It was used ex
in Humboldt Valley up to the time green food appeared i
A single treatment of the fields destroyed from 85 to 95
of the mice. Compared to the grain-phosphorus prepa
steadily gave as good or better results, and is about 30
cheaper; furthermore, it is entirely without danger to birds

Formula.

Chopped alfalfa hay	30 p
Strychnia sulphate	1 ou
Water	5 or

The alfalfa hay should be fresh and green rather than
Either chopped hay, including stems and leaves, or the fine
chiefly leaves and blossoms from the bases of stacks, may
The chopped hay is preferable, since the stems retain the
longer. The hay should be chopped into about 2-inch le
ordinary feed cutter being best for the purpose. The
quantity should be placed in a large metal receptacle, sprin
3 gallons of fresh water, and well mixed with a pitchfork.
1 ounce of strychnia sulphate in 2 or 3 gallons of water b

---

[a] Or as much as the hay will absorb.

ed vessel. Sprinkle the solution over the dampened hay and until the moisture is all taken up. The hay may now be nd is ready for use.

enough of the material for immediate distribution should red, as it deteriorates when kept for several days. It is best

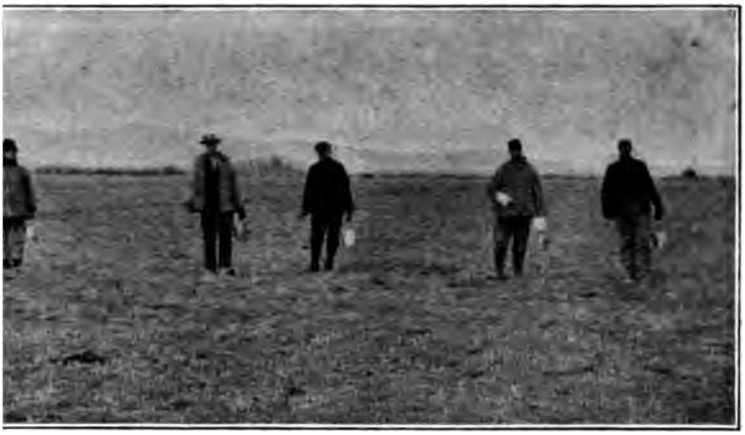

FIG. 5.—Men distributing poison.

ed by hand (fig. 5), placing a small pinch, equal to a tea- , near the entrance of each burrow, and scattering a little there along the surface trails. Care should be taken to place n a little to one side of the mound (fig. 6) to prevent it from vered by the earth ut. In cold weather, e mice move about ı their underground should be dropped urrows. The dampthe hay freshens it ly and makes it a substitute for green [any of the animals die on the surface, ıt 60 per cent of stroyed die under- The poison is ef- or several days, and since much of it is carried into the bur- e eaten later, its full effect is not at once evident.

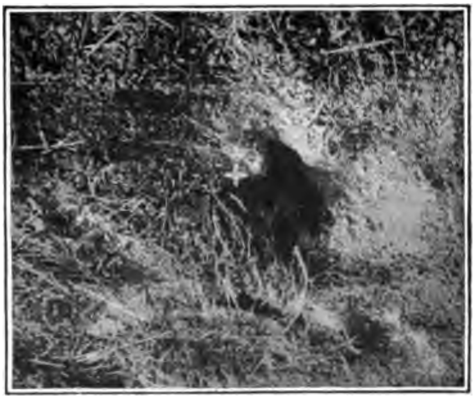

FIG. 6.—Where to place the poison.

farmers hesitate to distribute poisoned hay over their land of poisoning stock. If properly done, however, there is ly no danger. The proportion of strychnine is small and calculated especially for mice. Rain or the irrigation of fields re harmless any of the material left, and the small quantity it is sary to put out soon shrivels to almost nothing from exposure t sun. In Humboldt Valley extensive poisoning was not attend a single accident. It is recommended, however, that stock be out of fields for a few days after poison has been distributed.

Green alfalfa.—In Carson Valley, in April, poisoning with alfalfa hay was strikingly successful. Although the experimen alfalfa fields were in places where green food was abundant, nearly all the mice were killed in the areas treated (fig. 7).

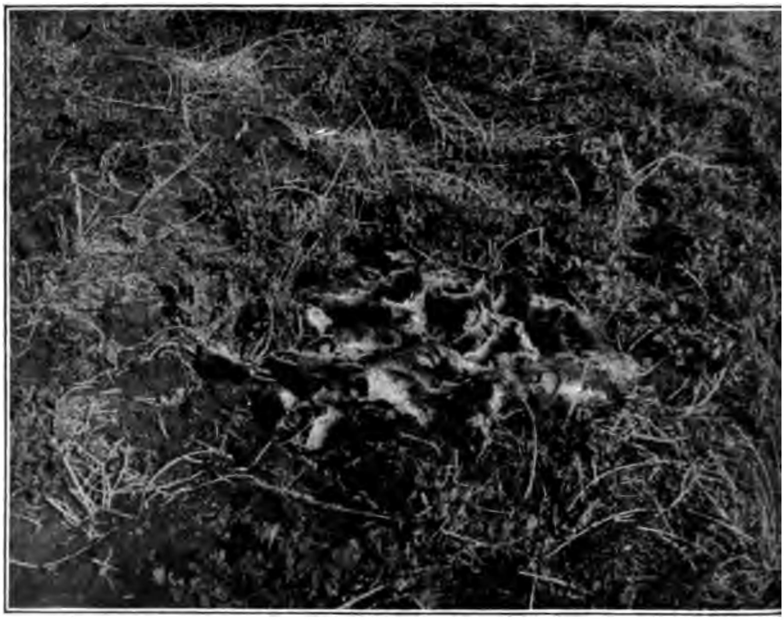

FIG. 7.—Field mice poisoned by green alfalfa.

animals habitually cut and store sections of alfalfa shoots d summer, and it is not surprising that the same material poisoned placed in their runs should prove effective.

Formula.

Green alfalfa	45 po
Strychnia sulphate	1 oz
Water	1½ ga

Procure fresh green alfalfa, preferably young shoots, though l and tops of older plants also are good. Chop into lengths of 3 inches and place in a water-tight receptacle. Heat the stry in half a gallon of water in a closed vessel until thoroughly diss Add the poisoned solution to one gallon of cold water and sprin wly over the alfalfa, mixing until the moisture is all taken up. general the same method of distribution recommended for alfalfa y should be followed. Several short pieces are sufficient for each rrow. Owing to the abundance of green food, greater care should exercised in placing baits in the holes and along runways. As en alfalfa withers quickly when exposed to the sun, evening hours cloudy days are best for its distribution. Though it can hardly used extensively enough to suppress well-established plagues, it recommended for small areas, or where mice are not excessively merous. It is especially valuable for destroying mice along ditch ıks or about the borders of fields during the irrigation of fields in nmer.

rushed wheat.—Crushed wheat possesses decided advantages over **le grain** as a medium for poison. It is easier to prepare, and is **readily** eaten, especially by young mice in summer. While con-**rably** more costly than the phosphorus preparation, it is much less **ctionable**. The cost is not serious when mice are not extremely **ndant** over large areas, or when it is used to prevent plagues in the **er stages**.

Formula.

ed wheat	60 pounds.
nia sulphate	1 ounce.
r	2 gallons.

eat the strychnia sulphate in the water in a closed vessel until **pletely** dissolved. Sprinkle the solution over the wheat and mix **.** Sweetening or scenting the preparation is unnecessary and even **imental**. When it is desirable to keep the poison several days, **two** tablespoonfuls of powdered borax to prevent fermentation.

his preparation was used extensively in Carson Valley in April to **ck** a plague of mice before alfalfa became too high to prevent ctive poisoning. About 85 per cent of the mice were killed by a gle treatment, and this was followed later by poisoning along the ches and in other places where the animals persisted. The cost was ut 40 cents per acre.

During these operations many blackbirds and magpies were poi-ıed. To a less extent meadow larks, killdeer, and mourning doves re destroyed. Though in this instance poisoned grain could not replaced by less destructive preparations, it should, when possible, re place to poisoned green alfalfa. Winter poisoning with alfalfa y will usually prevent the necessity for summer poisoning.

OBLITERATING BURROWS.

In the lands traversed by the scourge in Humboldt Valley, where er large areas mouse holes were scarcely a step apart, it was at ce evident that there was great waste of material and labor in poisoning. Usually there were ten or more holes for eacl mice, and in fields partially deserted the proportion of ur holes was much greater. When all the holes were obliter mice soon reopened those occupied, and poisoning could be d

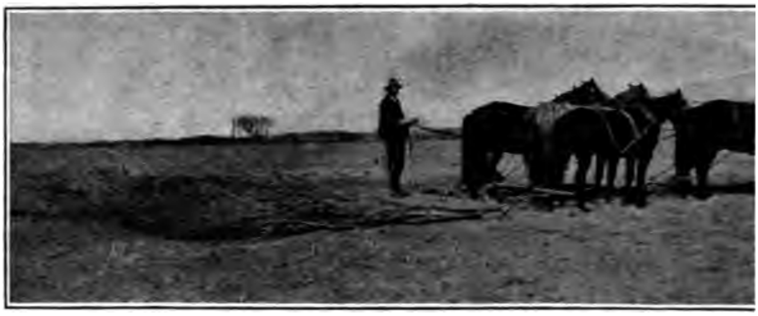

FIG. 8.—Brush drag used to obliterate mouse holes.

the certainty of treating only the occupied burrows. A br (fig. 8) proved best for the purpose. By this method a s about 40 per cent in labor and material resulted, and the ave of destroying mice with alfalfa hay was reduced to about

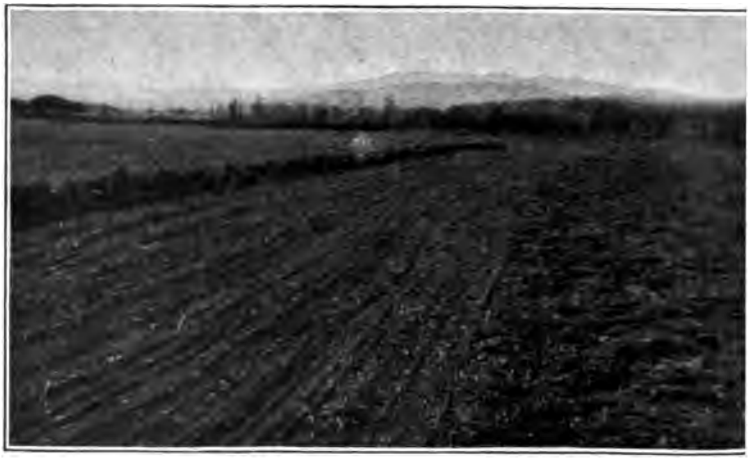

FIG. 9.—Effect of brush drag, showing mouse holes in part not dragg

per acre. While obliterating holes is practicable only un extreme conditions as were presented in Humboldt Valley it there proved of the greatest importance.

IRRIGATION.

Though irrigating in summer destroys a large percenta very young mice, it does not considerably reduce the n adults. Moving ahead of the flood, they dart in and out already full of water, swimming considerable distances through their underground tunnels. They cross ditches and furrows readily, traveling by water almost as easily as by land. Many take refuge in elevated spots and in straw or other litter in the fields, but by far the greater number are driven to the elevated ditch embankments and to the borders of fields. Within a few days after the water is withdrawn they again abound in the fields. Irrigation affords many opportunities for destroying the mice, both by poisoning and by dogs. [illegible] has also the effect of obliterating the burrows, so that for the next few days poisoning can be practiced with greater saving, since the occupied burrows are easily recognizable.

WINTER FLOODING.

It is said that flooding the fields in cold winter weather is an effective method of destroying mice, as when forced out of their burrows they soon perish from exposure, or are easily killed by dogs. This method has been successfully practiced in Carson Valley, and appears to be well worth trial. It can not be practiced in all irrigated districts, however, on account of the shortage of water at this season. It should be accompanied by poisoning along the ditch embankments and about the borders of fields.

BURNING.

In and about cultivated fields are many little areas where mice breed undisturbed. Waste strips along streams, swampy areas, and, on a larger scale, natural hay lands, serve as breeding places from which cultivated fields are invaded. Poisoning is not usually practicable in such places. Burning off the rank grass and weeds in winter or early spring is a great help in controlling field mice. Many of them perish, and the land is made uninhabitable for the survivors, driving them to locations where they may be more readily destroyed. In concerted attempts to control field mice, burning such areas should always precede poisoning-operations.

DESTRUCTION OF WINTER COVER.

Very important in any attempt to control field mice is the keeping down of rank grass and other cover along ditches and about the borders of fields. The grass in such places is frequently left in haying time, because of the difficulty in cutting it. The last growth of alfalfa is often left to be killed by frost, when it should be pastured off or otherwise disposed of. Such cover affords the mice excellent protection from hawks, owls, and other predaceous birds.

is season, where it is necessary to treat large areas quickly,
ned crushed wheat is the best agent to employ.

NATURAL ENEMIES OF FIELD MICE.

the many remarkable features of the mouse plague in Humboldt
y, none is of greater interest, or indeed, of greater significance,
the large numbers of birds and mammals which gathered to feed
e mice. In all other localities menaced these valuable allies of
farmer appeared in similar abundance. Under rows of trees,
t the bases of fence posts, and scattered everywhere in the fields
regurgitated pellets of mouse fur and bones, affording abundant
f of the services rendered by birds; while many holes and de-
ed nests in the fields showed the work done by skunks and
es. So apparent was the assistance rendered by these creatures
it attracted the attention and secured the protection of the farm-
many even sparing the coyote, whose services as a mouse de-
er deserve to be more widely recognized. In Nevada coyotes
frequently seen catching mice in the daytime, and their drop-
s were composed entirely of mouse fur and bones.

is deplorable that, even when their usefulness is as apparent as
some persons continue to destroy valuable birds and mammals.
ng the investigations in Humboldt Valley, no less than 29 large
s were found hanging on wire fences, their useful lives ended
oughtless gunners.

e striking evidence of the valuable services of the natural enemies
ice seen during this plague is but an example of their constant
. Hawks, owls, gulls, crows, ravens, herons, and shrikes among
; and skunks, coyotes, foxes, weasels, badgers, and wildcats
g mammals habitually prey upon field mice, and are most val-
in preventing undue increase of these pests.

orough studies have shown hawks and owls to be most bene-
allies of the farmer, orchardist, and nurseryman.[a] Most species
y, and many of them never, attack poultry. But even were the
dations of the several species which kill poultry much more con-
able, a small price would be paid for their services in destroying
ts. In the Nevada valleys all species of hawks and owls are
ctly beneficial, and here rigorous protection can not be too
gly advocated.

nong mammals the weasel and the skunk are especially worthy
otection. They are most persistent enemies of mice, and are less
y to be driven out by civilization than are other mammals. When

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[a] e Circular No. 61 of the Biological Survey, Hawks and Owls from the
lpoint of the Farmer.

omptly suppressed, since under these conditions a plague may be
ll established by fall. But if in default of such preventive meas-
es a plague is well established, nothing short of systematic and
gorous poisoning will check it. This requires the employment of
ough men to cover the infested areas in a reasonably short time.

In localities where mice are present in destructive numbers, system-
ic effort to control them results not only in considerable saving to
e ranchman, but proves the best safeguard against more serious
mage.

On the enormous ranches of the West, the centers of abundance
ich form the starting points for general invasions may develop
the lands of persons who neglect to control them. If each ranch-
an will consider the suppression of field mice on his own land a
gular part of farming operations, such scourges of mice will never
cur.

Issued April 12, 1909.

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN 353.

LANE MEDICAL LIB.
SAN FRANCISCO

xperiment Station Work,

L.

Compiled from the Publications of the Agricultural Experiment Stations.

ERCIAL CLOVER SEED.
ER IN ALFALFA SEED.
VING POTATOES UNDER STRAW.
VERSUS INCUBATORS.
ARING FOWLS FOR MARKET.
ERVATION OF EGGS.
MOUND-BUILDING PRAIRIE ANT.
COAGULATION OF MILK IN CHEESE MAKING.
EFFECT OF ALKALI ON CEMENT STRUCTURES.
SILO CONSTRUCTION.
A CHEAP AND EFFICIENT STERILIZER.
A CHEAP AND EFFICIENT ICE BOX.
THE POWER LAUNDRY FOR THE FARM.

JANUARY, 1909.

PREPARED IN THE OFFICE OF EXPERIMENT STATIONS.
A. C. TRUE, Director.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1909.

EXPERIMENT STATION WORK.

Edited by W. H. Beal and the Staff of the Experiment Station Record.

Experiment Station Work is a subseries of brief popular bulletins compiled from e published reports of the agricultural experiment stations and kindred institutions this and other countries. The chief object of these publications is to disseminate roughout the country information regarding experiments at the different experiment tions, and thus to acquaint farmers in a general way with the progress of agricul-al investigation on its practical side. The results herein reported should for the st part be regarded as tentative and suggestive rather than conclusive. Further periments may modify them, and experience alone can show how far they will be ful in actual practice. The work of the stations must not be depended upon to duce "rules for farming." How to apply the results of experiments to his own ditions will ever remain the problem of the individual farmer.—A. C. True, rector, Office of Experiment Stations.

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UNIVERSITY

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EXPERIMENT STATION WORK.[a]

COMMERCIAL CLOVER SEED.[b]

Clean soil and clean seed are essential to a clean crop. These quirements are especially necessary when the crop to be grown is slow development in its earlier stages, as in the case of clover, 'alfa, and certain other, particularly the grass, crops. When land s been kept free from weeds and the seed bed carefully prepared is readily realized how great a loss results when noxious weed ›ds are introduced with the seed for a crop. As is pointed out by recent bulletin of the Connecticut Station, there is frequently ›at danger of securing in the open market clover seed of poor ality, and the advice is given that purchasers make sure of the ality of the seed before buying. Of fifty-one samples of clover d examined by this station three were heavily adulterated with ck medic and only ten were apparently free from dodder, and ɔ of these had a very low vitality. Only one-sixth of the entire mber of samples analyzed was fit for use.

Vith reference to the weight of the samples, it is said that clover d of average quality should weigh about 1.5 grams per 1,000 ds, making about 302,000 seeds to the pound. Of the samples mined twenty-six did not reach this standard. Two weighed y 1.27 grams or less, equal to 363,000 seeds to the pound, while the other hand two weighed 2.92 grams per 1,000 seeds, equal 236,000 seeds per pound. Sowing a certain number of pounds light seed per acre would put a greater number of seeds on the a than if the same quantity of heavy seed was sown, but under same conditions the heavy seed would be more likely to give a isfactory stand.

The vitality tests made under laboratory conditions showed an rage vitality of 86.6 per cent for the fifty-one samples, or, in er words, an average of 86.6 out of every 100 clover seeds in the mination tests had life enough to produce a sprout. This result

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A progress record of experimental inquiries, published without assumption of onsibility by the Department for the correctness of the facts and conclusions rted by the stations.

Compiled from Connecticut State Sta. Bul. 160. See also U. S. Dept. Agr., ners' Bul. 79, p. 17.

ceases, and when actively growing the stem may be cut into any number of es, each of which, if attached to clover, will continue to flourish. It flowers and luces abundant seed, which stocks the ground for the next clover crop. Clover sted with dodder lodges, mats together, can not be properly cured, and either use of the dodder present or the molding of the clover in consequence, has been wn to scour cows when fed out as hay.

n twenty-eight carefully tested samples from 18 to 11,615 dodder ds were found per pound of clover seed. It is pointed out that a ding of 8 pounds per acre of these two samples would place one d to every 300 square feet and two seeds to every square foot of d, respectively. From alfalfa seed the dodder seed may be sepa- ed by sifting in sieves made for this particular purpose, but owing he small size of red clover seed this method can not be applied in ning it from dodder.

DODDER IN ALFALFA SEED.[a]

he appearance of dodder in clover and alfalfa fields is generally t dangerous to the crop. The ordinary operations of mowing, ng, and hauling tend to spread this troublesome parasite, and every new center of infection the chances of the crop grow less. ecent circular of the New York Experiment Station at Geneva ribes the injury resulting from dodder in alfalfa fields as follows:

> dder is a yellow, thread-like twining weed which is exceedingly troublesome in a fields. It appears in circular spots 3 to 30 feet or more in diameter. At the r of the spot the alfalfa is killed out, while around the margin the ground is cov- with a mat of yellow threads which twine closely about the stems of the alfalfa s and slowly strangle them. The spots increase in size from year to year. Many have been completely ruined by dodder. It is not often injurious to other (except red clover), but once established in an alfalfa field it is very difficult to cate without killing the alfalfa.

s dodder is usually introduced with clover and alfalfa seed, the chase and use of dodder-free seed can not be too strongly urged. n seed, however, can not always be secured, and therefore clean- the seed is often necessary. Frequently neither the purchaser the seed dealer knows dodder seed, and consequently in many es the first proof of its introduction is the appearance in the field the weed itself. In view of these facts, the New York Station ommends that seed be examined before it is sown to determine presence of dodder.

lfalfa seed is larger than dodder seed and advantage was taken this fact by the station to perfect a method by which commercial lfa seed may be made practically free from dodder and safe to sow. was found that dodder seeds are readily removed by sifting through ire sieve having 20 meshes to the inch. Since ready-made sieves of mesh are not readily obtainable, it is advised to construct a light,

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[a] Compiled from N. Y. State Sta. Circ. 8.

wooden frame 12 inches square by 3 inches deep and tack
bottom of it 20 by 20 mesh steel-wire cloth of No. 34 Wasl
Moen gauge wire. (Fig. 1.) This quantity of wire cloth ou
to cost more than 15 or 20 cents. In case brass or copper w
is used the wire should be No. 32 on the English gauge. I
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sifting ma
when much dodder is present, and particularly if it is of t
seeded kind, two siftings, both made strictly as directed, are

In experimenting with this method it was observed that be
dodder seeds various other small weed seeds, broken seeds,
as well as some of the smaller alfalfa seeds, were also rem

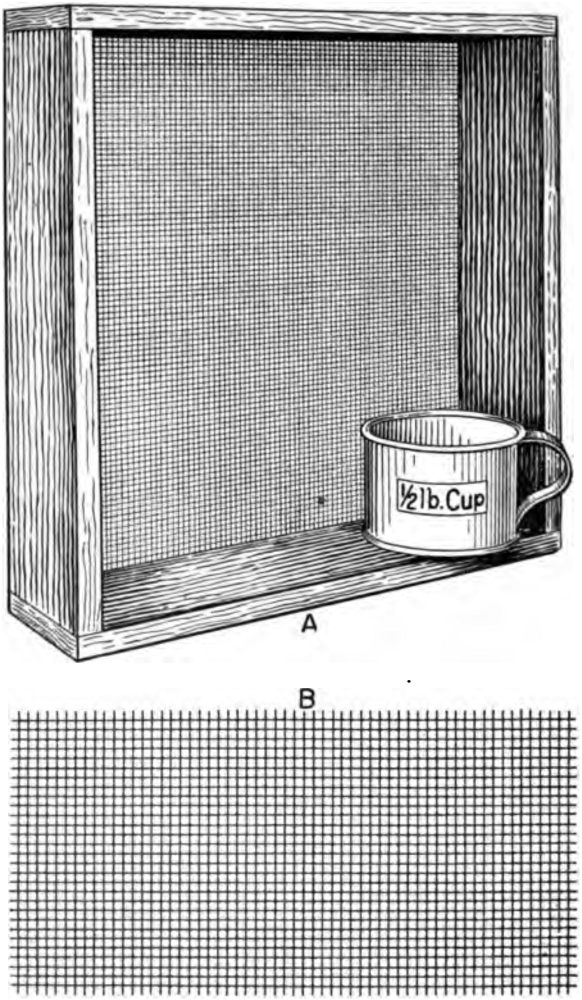

FIG. 1.—Tools required for sifting alfalfa seed to remove dodder seed: A, Home-made sieve 12 inches square by 3 inches deep; B, 20 by 20 mesh wire cloth made of No. 34 steel wire. (Natural size.)

ng. The siftings varied from about 1 to 5 pounds per bushel, ording to the original cleanness of the seed and the thoroughness he sifting. The rejection of the siftings is considered as causing little if any loss.

GROWING POTATOES UNDER STRAW.[a]

n a previous bulletin of this series[b] attention was called to the good ults obtained by R. A. Emerson, of the Nebraska Station, in grow- seed potatoes under mulch. Seed so grown was found to be, under warm dry summer conditions of Nebraska, much better than that duced by ordinary methods of culture. Mulching was also found rule to increase the yield, and the results in general indicate that ile mulching would not be practical on a large scale, on account of large amount of mulching material needed and the cost of appli- ion, it is entirely feasible on a small scale, as for instance, when the ner raises a few potatoes for his own table or when he wishes to e a few seed potatoes.

he practice has much to commend it in hot, dry climates, as the lch conserves the soil moisture, but is not so successful in a wet son unless the ground selected is well drained. Another reason the use of mulches is that it saves cultivation in the busy season, in this respect early mulching is preferable to late mulching.

writer in The Agricultural Gazette, of New South Wales, says:

> rhaps no other field or garden crop is more benefited by a liberal mulch of wheat (or other litter) than potatoes, and especially is this the case with the second planted, say, in January. If the soil be well fined, the potatoes planted closely covered shallow, and a mulch of from 1 to 3 or 4, or even 6 inches of straw ap- immediately upon planting, good results are sure to follow. The potatoes need no cultivation if the straw be applied at once before a packing rain. It ents the packing of the soil by such a rain, breaking the force of the descending , and letting them down to seep slowly into the soil; and, intervening between nd wind and sun, keeps it there, very largely, at least. It would be [a very] bad if potatoes failed to do well under such treatment.
>
> every farmer who grows wheat will try the following plan he will, in a figurative , convert his wheat straw into potatoes: As soon as the stripper has harvested grain, mow the straw with mowing machine or scythe and rake into windrows, horse rake or otherwise. Immediately plow and harrow the land between the rows, and plant the potatoes in the usual way, only they may be planted in rows r together than the usual distance, in order to economize the mulch. Plant in low furrows, and cover with the harrow, leaving the land perfectly level. Cover nce with the mulch of straw to whatever thickness you have straw sufficient for, the work is done. The potatoes will come up through the straw and flourish, never be troubled by weeds. No further cultivation will be necessary. When potatoes are gathered, many fine tubers will be found, not only in the soil and r the surface, but lying on the top of the ground just under the straw. * * *

Compiled from Nebraska Sta. Bul. 97; Agr. Gaz. N. S. Wales, 11 (1900), No. 1, 46, 47; 19 (1908), No. 3, p. 104.

U. S. Dept. Agr., Farmers' Bul. 305, p. 8.

If wheat straw is not available for mulching potatoes, bushes, suckers, an branches from trees laid thickly over the whole surface of the soil will be a very good substitute.

It is to be noticed that the above was written for a country th subject to periods of drought; also that January there correspon July in this hemisphere.

Another writer in the same journal describes an extreme ty the mulch method of growing potatoes, which may be used on h stiff lands not suited to potatoes, as follows:

> The ground is plowed deeply and harrowed into a good state of tilth; the pot are then placed by hand firmly in the soil until they are about half covered; 12 to 15 inches of wheaten straw is placed over them; this completes the pla Nothing more is done until the potatoes are picked—not dug—from under the s for they lie on top of the ground around the seed set. * * * The straw for protection from the sun and other destructive agents, the same as the earth does they are grown in the ordinary way.

This method of course commends itself only for small scale gar operations, but certainly has the advantages of ease and simplic Potatoes so grown can be easily removed from the hill from tim time as they mature.

A method of this kind has been used to some extent in certain p of this country, where it is known as the "lazy bed." While con ient and economical of labor, it of course is not to be recommen except where better methods of culture are not feasible.

HENS VERSUS INCUBATORS.[a]

The question of the relative merits of hens and incubators means of hatching chickens is of much importance to all who poultry on a scale at all extensive.

The person who raises only a small number of chickens will rule, do better to use hens for hatching purposes, while the mercial poultryman, who must be able to have stock ready for m at different times, is practically compelled to use incubators. ever, all studies of the relative efficiency of the two methods of h ing are of value since they may point the way for improvem the artificial method of incubation, bringing it gradually nea results to the natural method.

The Oregon Station has recently made studies of various pro of incubation, and the results bearing on relative efficiency o and incubators are summarized as follows:

(1) From 879 eggs set, incubators hatched 533 chicks, or 60.6 per cent.

(2) From 279 eggs, hens hatched 219 chicks, or 78.8 per cent.

(3) Eliminating eggs broken in nests, the hens hatched 88.2 per cent of eggs

(4) The incubators hatched 78.5 per cent of "fertile" eggs, and the hens hatch per cent.

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[a] Compiled from Oregon Sta. Bul. 100.

Eggs incubated artificially tested out 22.7 per cent as infertile, while those in-
ed by hens tested out 11.8 per cent.

The incubators showed 16.6 per cent of chicks "dead in the shell," and the
2.8 per cent.

Chicks hatched under hens weighed heavier than chicks hatched in incubators.

The mortality of hen-hatched chicks brooded in brooders was 10.8 per cent in
eeks, and of incubator-hatched chicks 33.5 per cent.

The mortality in hen-hatched chicks brooded under hens was 2.2 per cent,
f incubator chicks 49.2 per cent.

) In other tests the mortality was 46.5 per cent for incubator chicks brooded by
and 58.4 brooded in brooders.

) Hen-hatched chicks made greater gain in weight than incubator chicks,
er brooded by hens or brooders.

om these results Professor Dryden concludes that hens were
efficient hatchers than the incubators, though the incubators
hed a fairly satisfactory number of the eggs.

may be true in practice that the incubator will hatch as many chicks, on the
ge, as the sitting hen, because the hen sometimes breaks eggs in the nest and
imes quits her job, two things that the incubator is not guilty of, though occa-
ly the lamp will go out, the temperature will go wrong, and all the eggs will be
d. But this is a matter of care with the operator, and with fair care the loss
ccidents will be less in the incubators than under hens. It may therefore be
n incubator properly attended will, on the average, hatch as many chicks from
in number of eggs as a certain number of hens will hatch from the same number
of the same kind.

essful incubation, however, does not mean merely the hatching of a large per-
e or a certain percentage of the eggs; the serious problem is not how to hatch
eatest percentage of the eggs, but it is rather how to hatch the largest number of
of greatest vitality. The test of the incubator is not that it hatch, on the aver-
large a percentage of the eggs as the sitting hen, but that it hatch as many and
l chicks as a good sitting hen. Until this can be done poultry enterprises will
ue to lag where artificial methods of incubation are used.

he whole the results show that artificial incubation is responsible for the large
tage of chicks "dead in the shell," as well as for the large mortality of chicks in
oder. There are doubtless brooder problems affecting the vitality of the chick,
is fact should not obscure the plain demerits of artificial incubation. * * *
t the incubator is the cause of the mortality in the chicks was demonstrated in
ays: First, when hen-hatched chicks and incubator-hatched chicks were put
her in the same brooder, the former lived well and the latter showed a large death
and, second, it was demonstrated when hen-hatched chicks and incubator-
ed chicks were put together with the same hen or hens, the former lived well
he latter showed the usual mortality, or practically so.

considering the relative profitableness of the two methods,
unt should also be taken of the relative cost of labor.

he figures given above show that there was a marked difference in
ht of hen-hatched and incubator-hatched chicks. While the
e of this difference was not definitely determined in these experi-
ts, it was found that the adding of moisture to the incubators
ased the weight of the chick. Professor Dryden is of the opin-
however, that it is not a question of moisture alone, because he

found "that by increasing the moisture in incubators to
extent that the eggs lost less weight than eggs under hens n
the incubator chicks weighed less than the hen chicks, tho
moisture increased the weight of the incubator chicks."

The proper handling of incubators is fully discussed in a F
Bulletin of this Department.[a]

PREPARING FOWLS FOR MARKET.[b]

In continuation of his suggestions to amateur poultrymen
ously noted,[c] C. K. Graham in a recent bulletin of the Conn
Storrs Station gives directions for preparing fowls for the m
He states that "the method of killing not only affects the pl
of the fowl, but will to a large degree affect the quality of the

Chickens should not be chased or excited before killing, as
thought to have an unfavorable effect on the flavor and texture
flesh. To avoid this it is well to have a catching hook such as
scribed in a former bulletin of this series.[d] The best method of
is probably by bleeding, and is described as follows:

> Hold the head of the bird with the left hand, back of the head up, keep
> hand on the back of the neck to avoid cutting yourself should the knife
> pass through the top of the head. Take the knife in the right hand, the bac
> blade toward your body. Insert the blade in the mouth, keeping the point
> right side of the bird's neck and as near the outer skin as possible until it is
> the neck bone. Then press the edge toward the bone and slowly draw the kn
> the mouth, the hand moving from your body, so that the knife appears to pa
> the neck. Repeat the process on the left side of the neck. This should ca
> bird to bleed freely, but by holding the beak up the blood will remain in th
> giving you plenty of time to pierce the brain. The latter is located just ab
> eye and can be easily reached through the upper part of the mouth by usin
> steel blade, inserted in the mouth with blade edge up and pointing slightly
> eye. With young birds little trouble is experienced in piercing the brain,
> older birds a very stiff blade is required, as the bones are much harder. W
> point of the blade enters the brain, give the knife a quick twist to right or left
> the aperture. If the brain has been reached, the bird will attempt to squawk
> give a nervous jerk as the blade touches the spot, and this touching the brain
> not only loosens the feathers of the bird for dry plucking, but will greatly i
> the appearance of scalded stock.

A weight, which may consist of an old tomato can half fille
stones and cement, is immediately attached by means of a wir
to the lower mandible of the bird. "Then by grasping the
close to the back, the bird will not be able to flutter, and can be
and rapidly plucked. This, of course, should always be done wh
bird is bleeding. * * * The can catches the blood, and by
ing the bird over a barrel the feathers may easily be saved."

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[a] U. S. Dept. Agr., Farmers' Bul. 236.
[b] Compiled from Connecticut Storrs Sta. Bul. 52.
[c] U. S. Dept. Agr., Farmers' Bul. 237, p. 22.
[d] U. S. Dept. Agr., Farmers' Bul. 317, p. 31.

Since there is considerable difficulty in scalding birds properly and t is often improperly done, dealers usually pay a little more for dry-plucked birds.

The breast should be plucked first, starting near the crop. After the breast the highs, then the back near the base of the tail, and last the wings. As soon as the eathers have been removed the wings should be twisted over the back and the bird aken from the hooks and the feet washed, after which the thighs and legs should be pressed to the body either by placing a brick on the bird's breast or by tying the body, the object of this being to give the bird a plump or blocky appearance.

The birds should not be allowed to hang until they become rigid, as that causes them to look thin. Care must be taken that all animal heat has left the birds before they are packed for shipment, but this does not mean that it is necessary for them to hang while cooling.

As a rule, the head and feet are left on and the entrails are not removed, but such details depend on the requirements of the market to which the birds are sent. The following directions are given for preparing drawn poultry:

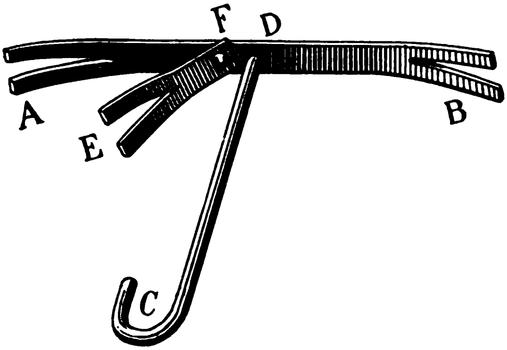

FIG. 2.—Hook used at Storrs Experiment Station to hold birds for plucking: A–B, bar; C–D, staff; E–F, arm.

Broilers.—Lay the bird on its side, draw the knife down the back, beginning between the shoulders near the neck, and cut through the backbone or along each side and remove the bone. Continue cutting past the oil sack and tail around to the end of the breastbone, then lay the bird on its breast. The entrails can then be easily removed, and the blood, if any, wiped out with a dry cloth.

Roasters.—Place the bird on its breast, head down. Inserting the point of the knife in the back just between the shoulder blades, continue the cut along the back of the neck to the head. Near where the blade first cut the skin will be noticed a white spot, which marks the joining of the neck to the backbone. By a little manipulation with the point of the blade the neck bone can be easily severed at this point. The aesophagus and wind pipe should then be separated from the skin of the neck, after which the head may be removed, making the separation from the skin of the neck as near the head as possible. The crop is then easily removed, and after being severed from the entrails, the latter, including the lungs, should be loosened from the frame of the bird by inserting the finger in this opening. The bird should then be placed with the vent up. Hold the vent with the left hand and cut around it, and in doing so loosen the main gut from the back of the fowl. In this way the entrails can be removed with little or no dirt, and through a very small opening.

Many consumers object to a roasted fowl on which the flesh has been drawn off the bones at the knee joints. This can be overcome by leaving a little of the yellow scale or shank on the back of the leg at the knee when removing the shanks.

All birds intended for roasting should have the sinews of the leg removed. To do this cut the skin of the shank lengthwise just back of the bone. With an eight-inch screw-driver raise the sinews, and by a twist of the tool these may be parted. They can then be pulled easily by holding the leg and screw-driver as you would a bottle and corkscrew.

A convenient hook for holding fowls for plucking is shown in figure 2. The bar A–B is of quarter-inch iron 1 inch wide and 18 inches long, with a split 3 inches long and about three-fourths of an inch wide at each end. A 5-inch arm E–F is riveted to A–B 1½ inches from D, making the distance from B to E about 15 inches and providing for fowls too small to spread from A to B. The staff C–D is of half-inch round iron 18 inches long with a shoulder at D and riveted on the under side of A–B, so that the latter will swing freely.

PRESERVATION OF EGGS.[a]

The best means of preserving eggs, particularly methods in which water glass is used, have been discussed in several earlier bulletins of this series,[b] and much has been written on this subject, but the question of securing eggs in the best possible condition for preservation has heretofore received little attention. G. H. Lamson, jr., of the Storrs Experiment Station, has, however, recently reported investigations on the causes and sources of infection which may result in the spoiling of eggs and on the best practical means of securing clean, sound eggs for preservation in water glass.

It was found that eggs may be infected with the bacteria of decay in the oviduct before the egg is laid, and through pores and defects in the shell after the egg is laid. Much can be done to reduce the chances of infection and to reduce or prevent the injurious effects of infection, thereby greatly improving the keeping quality of the eggs. In the first place the hens should be kept in as nearly perfect health as possible and should be given enough shell-forming food to enable them to make strong shells of uniform thickness.[c] Clean nesting places are necessary to prevent infection in the nest. The eggs should be gathered daily and kept in a dry, cool room or cellar where the sun's rays do not fall directly upon them. Only clean eggs should be used for preservation and these should be placed in the preservative within twenty-four hours after they are laid.

Eggs laid during April, May, and early June were found to keep better than those laid at any other season. It is recommended, therefore, that only eggs laid at this season be preserved. It was found that water glass when properly made seals the eggs to prevent further infection and when kept at a comparatively low temperature prevents the multiplication of bacteria (decay) within the egg. Water glass can usually be obtained through druggists at from $1 to $1. per gallon, a gallon of the water glass being made into 10 gallons reservative by simply dissolving it in 9 gallons of water which has een boiled and cooled before use.

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[a] Compiled from Connecticut Storrs Sta. Bul. 55.

[b] U. S. Dept. Agr., Farmers' Bul. 296, p. 29.

[c] U. S. Dept. Agr., Farmers' Buls. 186, p. 26; 225, p. 26.

The preserved eggs should be kept in a cellar or room of even emperature which does not go over 60° F.

If care is taken to select clean, sound eggs, and proper precautions re observed in carrying out the details of the method of preservation s above indicated, it is believed that water glass furnishes a cheap, eliable, and easily employed preservative for domestic use, "and y its use everyone having a supply of fresh eggs in the spring can ake a considerable saving, and at the same time have a larger umber of fresh eggs to use in the winter."

THE MOUND-BUILDING PRAIRIE ANT.[a]

In a recent bulletin of the Kansas Station, T. J. Headlee and G. A. ean describe the prairie ant and the mounds they build and discuss heir economic importance from an agricultural standpoint. It is hown that "while it is true that they destroy a small percentage of ultivated crops, their substantial claim to the title of injurious insects es in the annoyance caused the farmer in cultivating and harvesting s crops and in the discomfort resulting from their efforts to protect eir habitations when occupying public streets, sidewalks, much-used ths, dooryards, and corrals."

The ant mounds are found throughout western Kansas and the ighboring States, comprising the Western plains. They are some-nes circular, but usually elliptical at the base, and are from 2 to 6 et in diameter and vary in height from a few inches to as much as 2 et. The ants clear a circular space around their mounds, removing l vegetation from it to a distance of 5 to 10 feet from the mound on l sides; the mound is usually exactly in the center of the cleared ace. The outside of the mounds is covered with gravel or other arse material that may be at hand, such as cinders, bits of coal, and e like. This covering is from one-half to 1 inch deep, and the sides f the mound are made as steep as the covering material will allow.

The mounds have from one to three funnel-shaped openings, and in few cases a still larger number, through which the workers pass in nd out. The large end of the opening is toward the outside, and the penings are commonly about one-third the distance from the base to he top of the mound. These openings are closed about sunset or uring the day at the approach of a storm and opened in the morning bout 8 or 9 o'clock in summer. The closing is done so well that a ery close examination is necessary to determine where the openings ave been.

On hot days in summer the workers return to the mound before oon and remain inside during the hottest part of the day, but on cool ays the entire day is spent outside.

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[a] Compiled from Kansas Sta. Bul. 154.

Under the coarse covering of the mound is a rain-proof roof made of particles of soil cemented together. Beneath this the mound and the soil directly under it to a great depth is honeycombed with circular chambers from 1 to 3 inches across and from one-half to 1 inch high. These chambers are connected by galleries about three-eighths of an inch in diameter and of various lengths. Some of these chambers are filled with seeds of any kind that are small enough for the ants to carry and that are near to the mound; other chambers are occupied by the young in various stages of growth; and still others serve as rooms for the adult ants.

The ants are of three classes—males, fertile females, and sterile females; the latter is the working class and is by far the most numerous. It is estimated that large colonies may have 10,000 workers. The ants vary in length from three-sixteenths to seven-sixteenths of an inch. All the females have large mandibles and stings.

These ants are not pests in the usual sense of the word; as long as the country which they inhabit was sparsely settled they did no harm. Since the country has become more thickly settled, so that they come into close contact with man, they have become a source of annoyance.

> The ant colonies are usually too scattering materially to decrease the yield of any important crop. Even in alfalfa, where the damage occasions most complaint, they are chiefly troublesome as an obstacle to harvesting. In a 7½ acre field at Hays City, Kans., thirty-four colonies had cleared a space amounting to between 1 and 2 per cent of the total area, and most of them had constructed mounds of sufficient size to compel the mowing machine to pull around them. To attempt to mow through or over them would have choked the machinery and ruined the cutting edge of the sickle. Should a driver have such trouble in passing over a mound it would be most unwise for him to stop and try to adjust his machinery, for such a disturbance would bring the ants forth in angry swarms, each individual eager to do her utmost to repel the invader. Every one that succeeded in getting on man or beast would seize clothing, hair, or skin between her mandibles, curve her abdomen downward, and deliver a thrust quite as painful in result as the sting of bumblebee or yellow jacket.
>
> Even if the mounds be leveled some days before the cutting, the difficulty is merely lessened, for the passage of the team and machine over the nest is sufficient to bring the ants out in readiness to attack when the intruder comes around again. To a less degree the same difficulty is experienced in raking and loading the hay.
>
> In the dooryard the ants not only render the lawn unsightly with their mounds but unhesitatingly attack the careless child who walks over or plays about their nest. In trodden paths the passage of man or beast is sufficient to bring them out ready for any unfortunate that may follow soon after, and in corrals their determination to defend their rights is a source of annoyance to stock.

The authors' study has failed to find any effective natural enemy of the ants, and a trial of various methods of killing them shows that fumigation with carbon bisulphid is the most satisfactory. The method is described as follows:

> Carbon bisulphid is evaporated under a practically air-tight vessel over one or more of the opened gateways of the mound. The vapor formed, being heavier than air, sinks downward through the burrows into the lowest parts of the nest and finally

mes to fill every chamber and passageway. Thus all the ants that are at home are uffocated. Many nests so treated were carefully opened to the lowest chambers and l the occupants found dead beyond possibility of doubt. Some nests were not pened until the next day after the fumigation and then not a living ant could be und. The following method of using carbon bisulphid has proven the easiest and ost efficient tried. Start fumigation when gateways are open; take a vessel, such s a galvanized-iron washtub, and place it bottom side up in such a manner as to cover he openings and as much of the mound as possible; if there are more openings than the ub will cover they should be closed by throwing some of the surrounding soil over them; lace under the tub, in a shallow pan or dish, near the opening, 1 to 3 ounces of carbon isulphid, depending on the size of the nest; quickly pack soil around the edge of he tub, making it as nearly air-tight as possible; allow to stand thus for about five hours. he experiments show that breaking open the mound before setting the fumigation s of no advantage, nor did the practice of pouring the fluid into the broken-up mound ive any better results than that of evaporating it from a shallow pan.

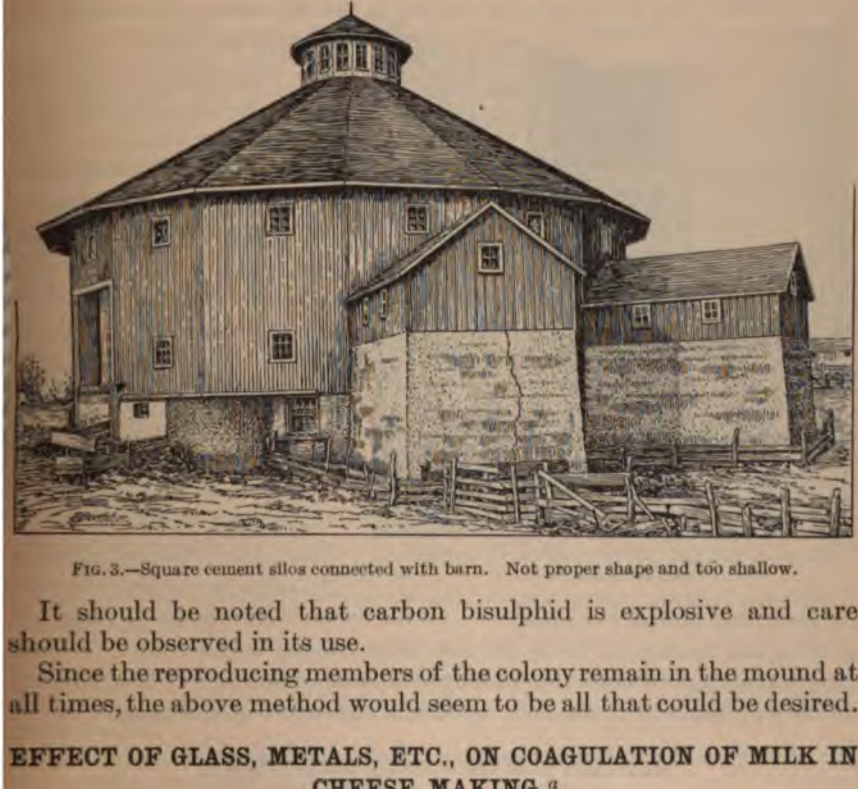

FIG. 3.—Square cement silos connected with barn. Not proper shape and too shallow.

It should be noted that carbon bisulphid is explosive and care should be observed in its use.

Since the reproducing members of the colony remain in the mound at all times, the above method would seem to be all that could be desired.

EFFECT OF GLASS, METALS, ETC., ON COAGULATION OF MILK IN CHEESE MAKING.[a]

One important problem with which the cheese maker has to deal is the irregularity in the coagulation of milk with rennet. This irregularity may be traced to a number of sources, such as variation in the strength of rennet extract used, the quality of the milk, and the kind of utensil employed. Experiments were made by G. A. Olson, of the

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[a] Compiled from Wisconsin Sta. Rpt. 1907, p. 134; Bul. 162.

Wisconsin Station, to discover the effect of different metals (platinum, tin, copper, nickel, iron, aluminum, and zinc) as compared with glass on the length of the coagulation period. "The experiments were conducted by placing milk in contact with [the] various metals for definite periods of time and afterwards observing the time required for the coagulation of such milk, with a standard solution of rennet, under uniform conditions." It was found that with the single exception of aluminum each of the metals tried produced a prejudicial (retarding) influence on the rennet action. The most striking influence observed was in the case of milk in contact with pure nickel. Milk which had stood in contact with this metal for twenty-five hours at 87° F. required four hundred and twenty minutes for coagulation with rennet and showed an acidity of 0.167 per cent. Under the same conditions milk in contact with glass required only nineteen minutes for rennet coagulation and showed an acidity of 0.207 per cent. However, as milk is hardly ever kept in nickel or nickel-plated utensils, the retarding effect of this metal has little significance from a practical standpoint. Copper also exerted a decidedly retarding effect, and as this metal is used more or less extensively in the form of heating disks in continuous pasteurizers in creameries and as kettles in the Swiss cheese factories, its retarding action is a matter of more practical importance. Apparently glass exerted a more or less accelerating influence on rennet coagulation and was to this extent beneficial in action. The degree of effect was directly dependent upon the character of the glass.

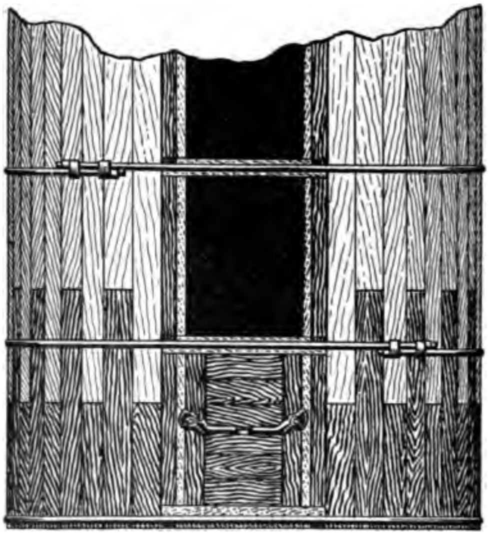

FIG. 4.—A silo with redwood staves at the bottom; cheaper wood above.

THE EFFECT OF RUSTY MILK CANS.

The experiments referred to above showed that both tin and iron have a prejudicial influence on rennet action. This suggested the desirability of determining whether or not rusty cans have a similar influence. Part of a sample of milk was placed in a rusty tin pan (with about fifteen rust spots in the bottom of the pan) and the remainder was kept in a Jena glass vessel (beaker) for comparative purposes. The milk kept in the rusty pan gave evidence of a retard-ng influence on the rennet action as compared with that kept in the glass beaker. "It required from one to sixteen and one-half minutes longer for the same milk kept in the rusty pan to coagulate than in case of the milk kept in the glass beaker." Wherever there was a retarding influence on the rennet action there was also a retardation of the acid development as well, but the latter was not sufficient to account for the delayed rennet action.

Milk which had been allowed to stand in iron dishes for several hours had a peculiar bluish gray color, indicating the presence of iron in solution. In several instances the amount of iron dissolved in the milk was determined as iron oxid. The maximum quantities of iron dissolved in the milk ranged from 1 to 1½ pounds for every 1,000 pounds of milk. The lower acidity of the milk kept in contact with iron also supports the view that the acid of the milk acts upon the iron and finally causes it to pass into solution [retarding rennet action].

Milk comes in contact with iron in the form of rusty cans or poorly tinned utensils in practically all creameries and cheese factories. The quality of the milk will to a large extent depend upon the condition of utensils into which the milk is poured, kept, and finally hauled to the factory. The degree of influence of iron on milk will depend largely upon the temperature of the milk, the length of time kept in the cans, and the amount of exposed surface.

Conditions in north European dairy countries.—In progressive dairy countries of northern Europe the quality of dairy products manufactured is generally uniform, and every precaution is taken to maintain a uniform product. Cleanliness is generally practiced at both the farm and factory. The utensils used are of superior quality, and naturally there is no occasion to consider this problem seriously. As a rule, the European utensils are stronger; the cans, for example, are of heavy steel and well tinned. Experience shows that these heavy cans are the most economical in the long run, and there is less danger of denting in or wearing off of the tin.

Conditions in America.—It is not necessary to describe here the American milk can, and especially the cheaper ones; if not the first time, surely the second or third time these cans are used one will find places where they have been dented in. As the number of indentations increase the tin begins to crack, leaving fissures or inroads for milk and water and acid. Often this thin layer of tin does not cover all of the iron, thus leaving microscopically small surfaces of iron exposed, which also become the sources of damage by water and acid. Under such conditions the tin peels or falls off, and it is then only a short time before the cans become unfit for use.

The attention of the milk producer and the factory operator is called especially to the following points:

(1) A better grade of utensils should be used in the handling of milk and its products. The iron or steel plate should be heavier and more thickly coated with tin.

(2) No milk should be accepted at a factory which has been kept in iron exposed pails or cans.

(3) The factory or creamery should be an example of neatness and cleanliness, with all utensils in first-class condition.

(4) Cooperation among the proprietors of creameries, cheese factories, and city milk supplies will tend to bring about cleanliness among patrons and the use of better utensils.

(5) Milk should be bought on its merits, by some satisfactory arrangement following well-founded sanitary and hygienic rules, by which the production of milk of superior quality is encouraged and milk of low grade either rejected or gradually improved.

THE EFFECT OF ALKALI ON CEMENT STRUCTURES.[a]

E. T. Tannatt, of the Montana Station, and W. P. Headden, of the Colorado Station, have recently called attention to certain facts observed in the course of their investigations which have a very important bearing on the use of cement in farm structures, a use which has rapidly grown with the increasing scarcity and advancing price of timber, viz, the action of alkali on the cement used in concrete structures.

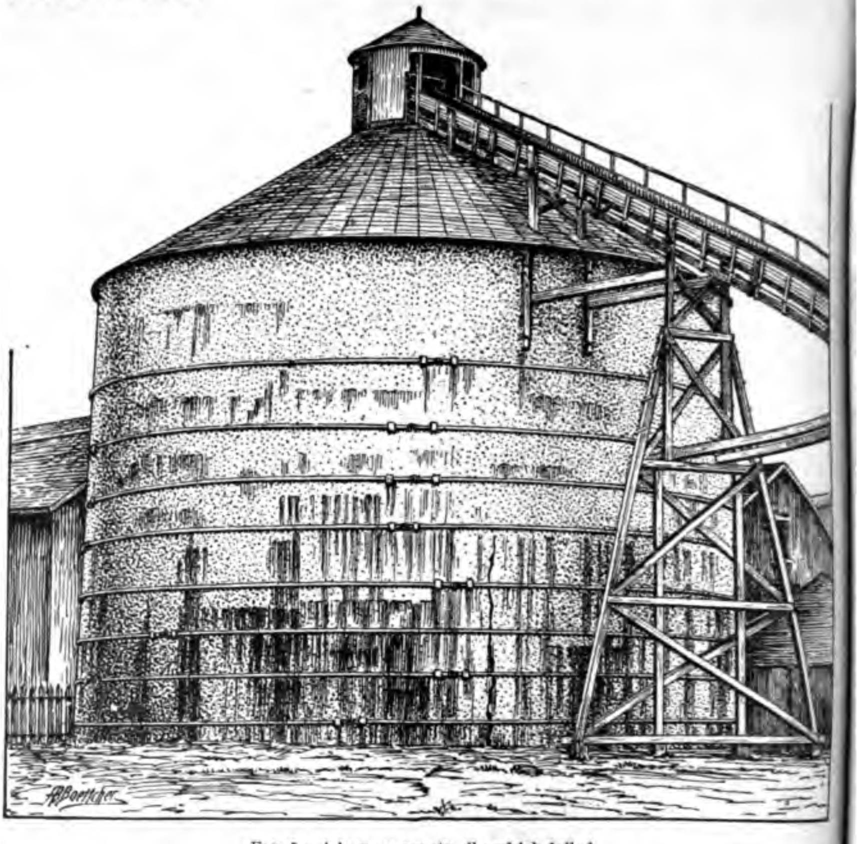

FIG. 5.—A large concrete silo which failed.

Professor Tannatt says.

> Cement is being generally used for the construction of culverts, flumes, bridges, foundations, retaining walls, curbings, etc. It has also been largely used in various parts of the canals, conduits, dams, etc., constructed by the United States Reclamation Service on their irrigation projects. A large number of the private irrigation and drainage projects of the West also make use of cement construction to a large extent. Conditions are pointing to a more general and larger use of cement in the structural works of the future. This material is also becoming more and more generally used in agricultural construction. In fact, it is difficult to prophesy to what extent cement may enter into the development of the resources of the country.

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[a] Compiled from Montana Sta. Bul. 69 and Colorado Sta. Bul. 132.

Professor Tannatt cites a number of cases of weakening or breaking lown of cement structures due to the action of alkali. As "the distribution of alkali is quite general, being found throughout the arid and semiarid regions of the Western States and in the Great Central Basin," the damage which may result from this cause is of grave mportance.

The examinations and chemical analyses (of a cement sewer) reported show that "the amount of disintegration corresponds closely to the percentage of alkali present." It was also found that sandstone s subject to similar disintegration under the influence of alkali. For his reason Professor Tannatt is of the opinion "that the use of sandtone in foundations, and for a couple of feet above the surface, is very inadvisable in the alkali sections."

As means of protection of foundations against the action of alkali t is suggested that—

> The ground on the exterior side should be excavated to the bottom of the foundation, the surface of the sandstone should be thoroughly cleaned with steel brushes and washed. Where the cement mortar shows signs of disintegration, the same should be removed and replaced with new material. After the surface of the foundation has been cleaned, the same should be given a good coat of hot asphalt, the coat extending sufficiently above the surface to include the alkali limit [2 feet above the surface]. In the bottom of the trench thus made along the foundation, a small tile should be laid which will drain any water away from the foundation, or into the city sewer. The trench, at least a portion along the face of the foundation, should be back filled with clean gravel or crushed rock to within a foot or so of the surface of the ground; above this may be placed earth for lawn, if desired.
>
> Concrete foundations for buildings are being used very extensively. Where any large amount of alkali is present in the soil, we believe that cement should not be used, unless thoroughly protected from the action of the alkali salts. This should be accomplished by thorough and proper drainage, and the use of some method similar to that suggested for sandstone foundations.

Professor Tannatt also calls attention to the possibility of harmful action of alkali in the case of cement sidewalks.

> In the construction of cement walks in the alkali sections, we would recommend that special care be taken to use clean gravel or broken stone. The use of soil in foundation gravel will furnish a means of bringing the alkali in contact with the lower portions of the cement. It is also advisable, we believe, that where the gravel or broken stone foundation is liable to become filled with water, to place a small drainpipe discharging into the gutter. We feel that with the present knowledge of the situation too much care can not be taken to prevent the alkali coming in contact with cement construction, either through the agency of standing water or the capillary action of the soil.
>
> The general recommendation is made that wherever cement construction is used in the alkali sections, a mortar made of granular sand should be used, and the mortar should be of maximum density.

SILO CONSTRUCTION.[a]

The general subject of silos and silage has been fully discussed in previous Farmers' Bulletins.[b] It is the purpose in this article, mainly on the basis of data reported by a number of the experiment stations, to point out some faults of silo construction which more extended experience has revealed, and to indicate, if possible, how these faults may be corrected and the general construction of silos improved, for, while it is generally conceded, by dairymen particularly, that the silo has become a necessity, occasional silo failures have discouraged the use of silage to some extent.

FAILURES OF SILOS.

Some of the failures of silos have been due to carelessness in filling, but more frequently to faulty construction of the silo.

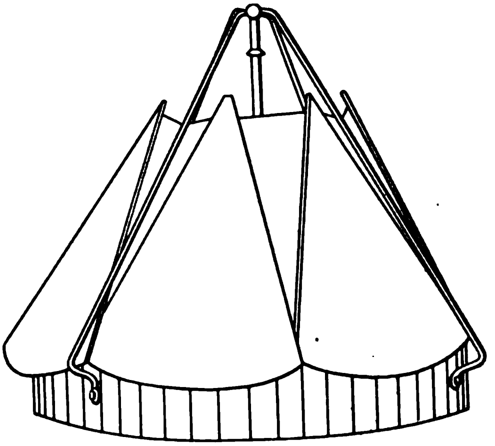

FIG. 6.—The patent roof of a silo, open.

Formerly many silos were made by sheathing one of the bays in the barn. With these silos and other forms of wooden square silos a lining must be built across the corners and the silage well tramped down along the edges or there will be considerable loss of what would otherwise be valuable stock feed. This style of silo, however, has become less common, and but few square silos of any kind are built at the present time. Even when silos are built inside of a barn they are often circular. Figure 3 shows a square silo that can not be recommended, not only because it is square but because it is not deep enough. The octagon silo is an improvement over the square form, but as a rule the walls of this form of silo have not been made rigid enough. The details for constructing the octagon silo were given in a previous Farmers' Bulletin.[c]

Too often the walls of silos are not made air-tight. Unless the walls of wooden silos are made air-tight, with tar paper, felt pads, or clay worked into the joints, much silage will be wasted. Ninety cent of stave silos are not air-tight at the foundation. The nkage and swelling of staves breaks the cement, which must frequently mended. Some losses have occurred because the s of the staves have decayed. Figure 4 shows how some ble wood may be used at the bottom of the silo, which is method of overcoming this difficulty. The iron bands of the e silo must frequently be examined, or they will fall down as the es shrink. Sometimes the iron splices rust. Unless a stave silo

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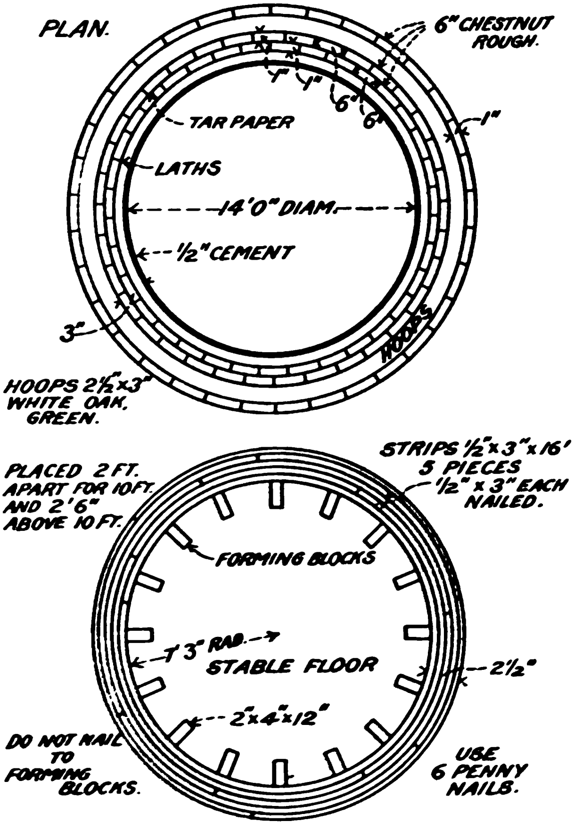
[a] Compiled from Illinois Sta. Bul. 102; Iowa Sta. Bul. 100; Maryland Sta. Bul. 12[illegible]; Wisconsin Sta. Bul. 125.

[b] U. S. Dept. Agr., Farmers' Buls. 32, 292.

[c] U. S. Dept. Agr., Farmers' Bul. 190, p. 21.



.—Showing method of making hoops and details of the construction of a stone and stave silo.

ell anchored it may be moved from its foundations or even blown n. A further discussion of the stave silo may be found in a pre- s Farmers' Bulletin.[a]

he walls of the silo must be rigid or they can not stand the pres- . Figure 5 is an illustration of a silo, the concrete walls of which not rigid enough to withstand the inside pressure. When the sides begin to bulge, air can get between the silage and th Brick silos without reinforcement have been failures because pressure from the inside.

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[a] U. S. Dept. Agr., Farmers' Bul. 103, p. 23.

A mistake sometimes made was in building the silo of to a diameter for the size of the herd, so that the silage spoiled long exposure of the surface. In one case a man with a sma built a silo in his barn 18 feet square and 16 feet high. Aft years' trial he gave up the use of the silo in disgust because hi did not keep. A year or two later he sold his farm to a mo gressive man, wh partitions across th silo, making four silos out of the lar and had no diffic obtaining good sil stock. The silos be deep. The dee silo the better the The diameter shou form to the size herd, and if 2 in silage are fed ea there will be no lo surface exposure.

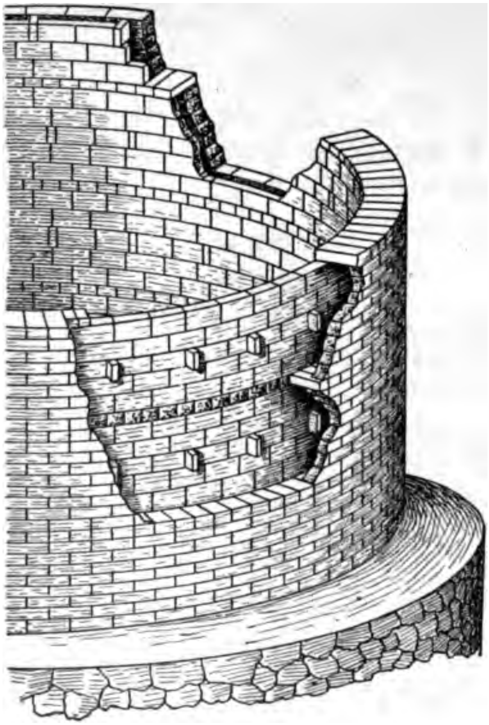

FIG. 8.—Double wall brick silo.

It is desirable to p silage from freezin double wall concre and those built tangular building t complish this obj well as any. Ston prevent freezing, but owners of stone si not like them b moisture collects on the inside of the walls and rots the silage the edge. A roof helps to keep out the frost, rain, and snow. 6 shows a patent roof which allows the silo to be filled above th

MATERIALS FOR SILO CONSTRUCTION.

Most silos in this country are made of wood, but the high p lumber has led to the use of other materials for all kinds o buildings. Experiment station workers have been investigati desirability of using earthen and metal substances for silo co tion. The cross section of a homemade combination of sto stave silo in Baltimore County, Md., is shown in figure 7.

ıg are set on a stone pit 8 feet deep and 14 feet in diameter,
total height of 28 feet. The details of construction are
:

s on outside are chestnut, 6 inches wide, nailed on vertically 16 feet long,
ıailed above. The 4-foot pieces are nailed on so as to lap on the 16-foot
ving the water to run off.
ior is vertically lined with 6-inch chestnut, tar paper placed, and again
-inch chestnut, joints being broken, then the vertical laths are placed,
h horizontal, and then plastered with cement. The bottom is cemented
ape. This silo is not affected by atmospheric conditions. The cement
enough to
weat, and it
a preserver
silo, there
lecay from
This manner
tion is the
t combina-
t was found.
and frame
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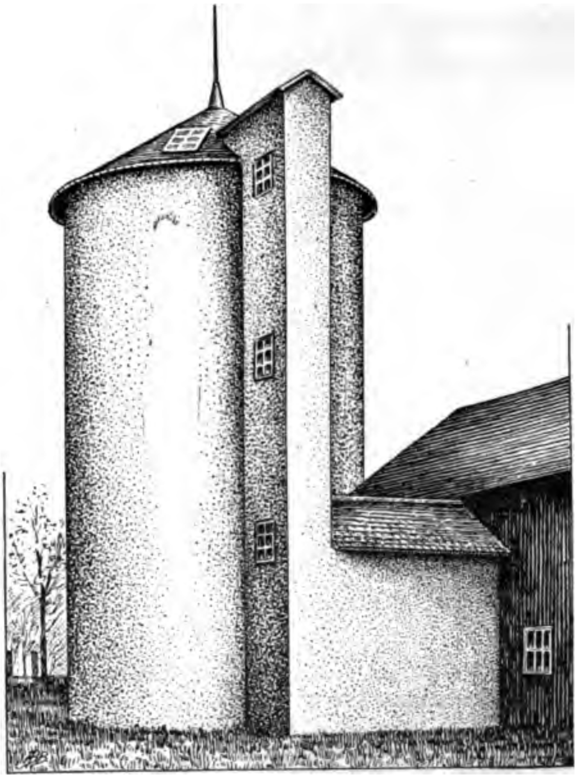

FIG. 9.—Double wall concrete silo.

ving is a list of the material required:
½ inch by 3 inch by 16 foot white oak for hoops.
1 inch by 6 inch by 16 foot chestnut staves } outside.
1 inch by 6 inch by 4 foot chestnut staves }
1 inch by 6 inch by 16 foot chestnut staves } inside first course.
1 inch by 6 inch by 4 foot chestnut staves }
ot piece nailed from top and 4 foot at bottom. Next stave 16 feet from
4 feet on top.
feet of tar paper.
1 inch by 6 inch by 16 foot chestnut staves } inside second course.
1 inch by 6 inch by 4 foot chestnut staves }

2,600 rough laths.
20 pieces 2 inch by 4 inch by 16 foot rafters for roof.
200 feet 1 inch by 6 inch sheathing.
2,000 shingles.
18-inch stone wall.
24 perch of stone or concrete.

Doors are concave, built of staves, lined with paper, placed on two battens.

It may be questioned whether steel silos will come into gene
Galvanized iron is an excellent method of protecting a wood
when located out of doors. Many stone silos have been bui
some care must be taken to make the inside walls smooth. C
mortar should be used and the walls must be reenforced by b
steel bands into the wall.

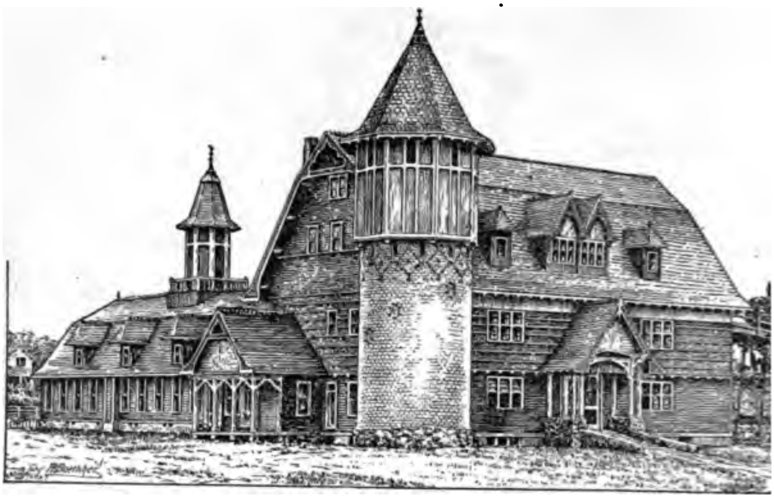

FIG. 10.—Dairy barn and stock-judging building, erected in 1898.

Clay pipe silos are giving good satisfaction, but are expensiv
tubes are set on end with the slots interlocking. Steel bands o
are placed around the wall and then plastered smooth with
plaster. Rectangular building tile is recommended by th
Station as a good material for silo construction. Cement blo
have been satisfactory when reenforced by steel within the
The inside of the silos should be plastered. The block is holl
this prevents freezing. Brick silos are successful, but like the
block must be reenforced in some way. Figure 8 shows a speci
of double-wall brick silos.

The single-wall concrete silo is the most common style of construction. Th
ness of the walls of silos now in use varies from 6 inches at the bottom to 4 i
the top for the lightest wall to a wall 2 feet in thickness, which is the heaviest
the section has record. Six inches seems to be the most desirable thickness

·s of silos under existing practice. The walls might be made lighter at the
the saving of material would hardly balance the trouble of varying the size
rms. The double wall concrete silo at present is made only with a patented
'igure 9 illustrates a double wall concrete silo made by forms owned by the
Cooperative Concrete Silo Company. The inner wall is 5½ inches thick, the
ll 3½ inches thick, and the two tied together with steel ties with a 3-inch
between. Circulation is prevented by inserting horizontal tar paper parti-
ry 3½ feet. This construction, besides being as satisfactory as the single-wall
places it entirely above any
in regard to freezing. The
orms being of steel plate enable
nooth job to be secured.

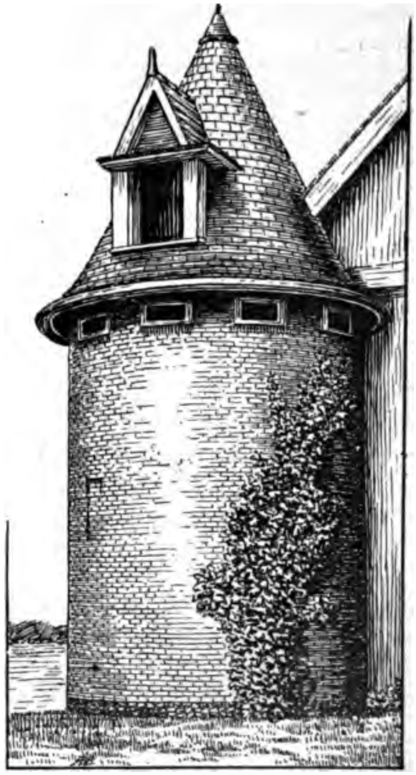
FIG. 11.—Brick silo, Iowa State College.

APPEARANCE OF THE SILO.

silo as sometimes con-
d is anything but an orna-
the farm. The situation
e style of architecture of
er buildings must be con-
if the farmer takes pride
ing his surroundings at-
e. Figures 10, 11, and 12
hat may be done with the
make it an ornament in-
f a disfigurement to the
ad.

EAP AND EFFICIENT STERILIZER.[a]

recent bulletin of the
Carolina Station, Prof.
lichels calls attention to
t that "all vessels and ap-
s used in the handling of
eam, and butter should be
d sterile after washing, either by placing them in boiling water for
ive minutes or by steaming them for an equal length of time."
dairies without boilers should sterilize with hot water, but the larger dairies
it advantageous to use a steam boiler and sterilize with steam. To perform
ation efficiently, it requires a closed steam chest large enough to hold every-
at is to be sterilized. Sterilizers of this type are usually constructed of con-
brick and concrete, and are provided with a heavy iron door, this being
ugh to admit a truck bearing the pails, cans, bottles, etc. Still other steril-
is type are constructed of galvanized iron or boiler plate, and all permit of
g under more or less pressure.

rincipal drawback to these various steam sterilizers is the high cost, which
their use by the smaller dairymen almost prohibitive. After considerable
ntation and study, the writer has succeeded in constructing an efficient

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[a] Compiled from North Carolina Sta. Bul. 198.

sterilizer which will cost only about one-third as much as the cheapest sterilizer of the type just mentioned. The construction of this new sterilizer, whose inside dimensions are 7 feet long by 2½ feet deep, by 2½ feet wide, is very simple. (See fig. 13.)

Essentially, it is a rectangular concrete tank with a wooden cover, which is lined with zinc. The sides and bottom are 5 inches thick and are built of concrete, which is made up of one part cement, two parts sand, and two parts coarse gravel. A thin coat, consisting of one part cement and two parts sand, is used as an inside finish. A piece of 2 by 4 studding is placed around the top of the tank and is secured by six ½-inch iron rods, 2 feet long, embedded in the concrete walls, one being placed at each corner, and one on either side midway between the corners. This arrangement not only strengthens the tank, but also makes the cover fit tighter.

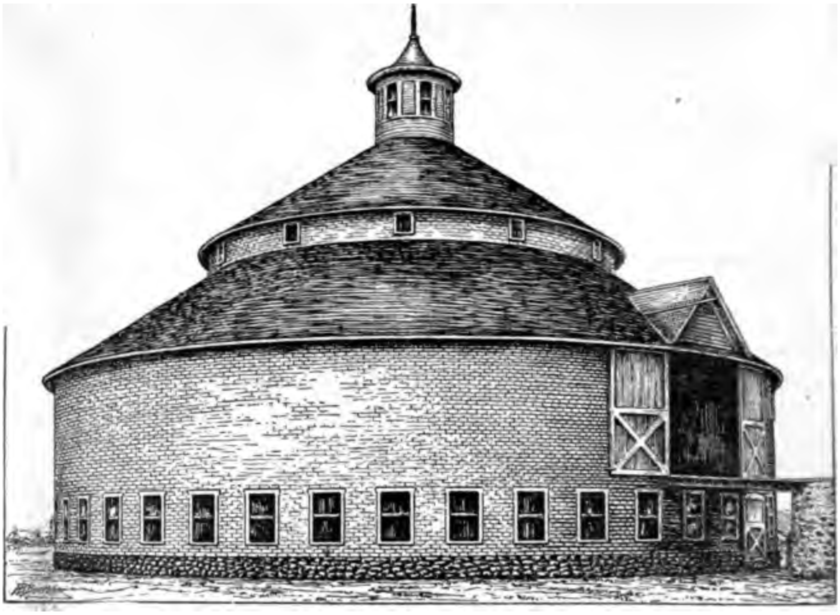

FIG. 12.—A circular dairy barn with silo in center 24 feet in diameter and 45 feet deep.

The cover consists of two thicknesses of 1⅛-inch tongued and grooved flooring 3½ inches wide. The upper boards run lengthwise and the lower crosswise of the tank. The lower boards fit into a shoulder projecting from the base of the 2 by 4 studding. The entire inside portion of the cover is covered with zinc. To insure additional tightness of the cover, a layer of asbestos is placed on top of the 2 by 4's. A safety valve, set at 10 pounds pressure, is inserted through the top of the cover at the most convenient place. An outlet for condensed steam is provided at the bottom.

The cover is raised and lowered in the same manner as that of the ice box described on page 29. The cover is strengthened by running three pieces of 2 by 4 studding crosswise of the tank, one at the middle and one at either end. The hinges, by which the cover is fastened, are attached to these 2 by 4 pieces, as shown in figure 13.

The following is an itemized statement of the approximate cost of the material of this sterilizer when the inside dimensions are: Length, 7⅓ feet; width, 2¼ feet; depth, 2⅓ feet:

2 barrels of Portland cement	$5.20
20 feet of 2 by 4 studding	.30
110 feet of 1⅛ tongued and grooved flooring, 3½ inches wide	4.40
4 hinges	.40
5 pounds nails	.20
6 ½-inch iron rods 2½ feet long	1.20
3 hasps	.30
20 square feet zinc	1.75
Ball and lever safety-valve	1.00
3 pounds sheet asbestos	.30
Total	15.05

The more extended use of efficient sanitary appliances on the farm should be encouraged, and this is most effectively done by indicating, as Professor Michels does in this case, cheap and simple methods of constructing such appliances. More sanitary methods of handling articles of food and drink would be more practicable and more generally used on the farm if some such convenient means of sterilizing appliances and utensils as Professor Michels describes were always at hand.

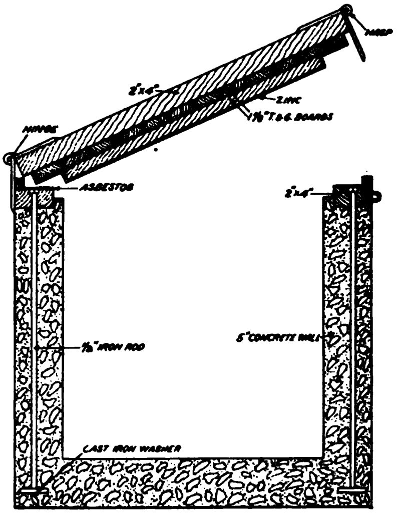

FIG. 13.—Cross section of sterilizer.

A CHEAP AND EFFICIENT ICE BOX.[a]

There is probably no need which is so severely felt on many farms, particularly in the South, as that of suitable cold storage for the preservation of meat, dairy products, and other food supplies, and as Prof. John Michels, of the North Carolina Station, points out, "cold storage of some kind is indispensable to a well-equipped dairy. Many, however, lack this essential, probably largely owing to the high cost of commercial refrigerators."

Professor Michels describes the construction of an easily made, cheap, and efficient ice box suitable for dairy purposes as follows:

The construction of the box shown in figure 14 consists essentially of two boxes separated by 1-inch strips placed at intervals of about 1 foot. Double thickness of building paper is placed on both sides of the strips and tacked to the boxes. A

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[a] Compiled from North Carolina Sta. Bul. 198.

1-inch strip 2 inches wide covers the upper space between the 1-inch strips, thus making a dead-air space between the two boxes. The construction of the cover is the same as that of the bottom, with the exception that there is a flange at the front and sides of the cover.

The sides, bottom, and cover of the refrigerator are built of ¾-inch tongued and grooved lumber 5½ inches wide. The ends are constructed of 1⅛-inch tongued and grooved flooring 3½ inches wide. The inside of the ice box is lined with galvanized iron. To insure tightness, a layer of felt is tacked around the box and cover where the two meet. The four vertical edges of the refrigerator are tightened and strengthened by tacking over each a double layer of paper, which is covered with two 6-inch boards.

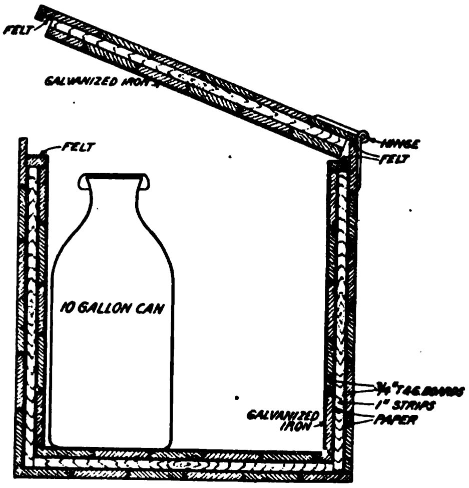

FIG. 14.—Cross section through ice box.

A heavy weight attached to a ½-inch rope running over a pulley fastened to the ceiling raises the cover and holds it open when desired. A short piece of rope with a hook attached is used to counterbalance the weight by hooking to the side of the box, thus allowing the full weight of the cover to rest on the box.

A short piece of ½-inch gas pipe is inserted through the bottom of the box to provide drainage, the outlet of this pipe being immersed in a cup of water to prevent entrance of air into the box.

The entire construction of the ice box is so simple that anyone with a little knowledge of carpentry can readily build it.

The inside dimensions are: Length, 7⅓ feet; width, 2¼ feet; depth, 2⅓ feet. An itemized statement of the cost is as follows:

200 feet ¾ inch by 5½ inch by 16-foot tongued and grooved lumber	$4.00
54 feet 1⅛ inch by 3½ inch by 16-foot tongued and grooved lumber	2.16
168 feet 1 inch by 1 inch by 12-foot strips	1.26
4 hinges	.60
½ yard felt	.63
15 feet ½-inch rope	.30
2 strong hooks	.10
1 2-inch iron pulley	.50
Carpentry work, 3 days	6.00
Complete lining with galvanized iron	11.25
500 square feet building paper	.60
Total	27.40

Commercial refrigerators of equal capacity and no greater efficiency will cost from $60 to $100, or about three times as much as the refrigerator above described.

A test of this ice box for six days with an average of 200 pounds of ice in the box showed that an average temperature of 39° F. was maintained within it, with an average daily consumption of 40½ pounds of ice, while the temperature of the room in which the ice box was kept averaged 74° F.

When 22 gallons of milk, which had been cooled to 45° F., were stored in the box eight hours daily with the other conditions as above, the average daily ice consumption for six days was 49 pounds, and the average temperature of the box 40° F.

While this box is designed especially for dairy use, it may easily be adapted to other cold-storage purposes, and so extend its usefulness on the farm.

THE POWER LAUNDRY FOR THE FARM.[a]

In an extended article recently prepared for the State Dairy and Food Commission of Missouri by Prof. R. M. Washburn, who was then commissioner, valuable suggestions are made for the planning and convenient construction of barns with reference to location, hygienic conditions, interior arrangement, and conveniences. Special stress is laid on the use of power for running a feed mill and other appliances, and the use of boilers for supplying hot water and other similar equipment essential for satisfactory dairy farms. The modern cleanly, convenient, and hygienic dairy barn means a great deal of additional work for the farmer's wife and her helpers, for white suits must be washed and there is a general increase in laundry work and similar work. It is only just that these added burdens should be offset by more conveniences and labor-saving devices. In general, it is not true that the farm home has kept pace with the rest of the farm in the adoption of improved methods of labor-saving devices and other conveniences.[b]

Professor Washburn's plans for a model dairy barn include a laundry, and interesting figures on the cost of equipment, the length of time the equipment may be expected to last, and similar matters are given. It has been suggested that a laundry such as he proposes might be used by a number of families in the neighborhood on the payment of a small fee and prove of great value to the adjacent farm community. Such ideas of cooperation applied to rural life are interesting as well as valuable and an indication of a means by which the farm housewives' labors may be lessened in a number of ways. A cooperative bakery or laundry seems as practical as the cooperative creamery which is now so common.

Professor Washburn writes on the subject of the farm laundry as follows:

> A laundry provided with stationary washtubs, with washer and wringer for power use, is an innovation. But why should not the woman of the farm be provided with modern appliances? Why should she be compelled to toil as her great-grandmother did? The farmer no longer reaps with a sickle, or even with a cradle. He rides his plow, and often his harrow. He rides his grain drill and corn planter and corn cultivator. He rides his grain harvester and his corn harvester. He loads hay by machinery and pitches it into the barn by horse power. The time is come when it

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[a] Compiled from Ann. Rpt. State Dairy and Food Commissioner Missouri, 1 (1907), pp. 129–165.

[b] The general question of conveniences in farm homes has been discussed in Farmers' Buls. 270, 296, 317, and 342.

is positive cruelty to compel, or even allow, the woman to toil on without running water or machine power in the house. The same steam, water, and sewage system that must be present for the dairy will take care of the laundry. The same power used for grinding feed and separating milk and pumping water and sawing wood will turn the washer and the wringer. Prices will vary somewhat, but the following will be a guide to the cost of equipping such a room:

Equipment and cost of a farm laundry.

Equipment.	Dimensions.	Horsepower required.	Length of service.	Approximate cost.
Stationary tubs	3 compartments, each 28 by 25 by 17 inches.		20 to 30 years	$50
Power washer	24 by 32 inches	One-half	10 to 15 years	35
Power wringer	18 by 24¾ by 30 inches	do	15 to 20 years	40
Piping and connections			10 to 20 years	5
Drying room (¾-inch steam piping)			do	10
Total				14

The investment of $140 for one year at 7 per cent equals $9.80; deterioration, assuming that they will require to be replaced every fifteen years, equals $9.35 per year, or a total of $19.15, or, say, $20 per year, or 38 cents a week; add to this 10 cents more for gasoline used by the engine. If the farmer were compelled to kill and dress two hogs every week throughout the year he would think nothing of spending 50 cents a week for machines which would save so much labor and enable him to do more work in less time. A power ironer, costing about $60 may be added, if desired. Such a laundry is to be desired, also, because it will practically insure clean garments worn by the milkers. A drying room, about 6 by 12 feet, located between the dairy room and the laundry room, provided with steam pipes for heating, will cost very little, and will insure quick, clean and easy drying in any weather. A power laundry like this may be rented to the neighbors for, say, 50 cents per day, they to come over and do the work. Such an arrangement will in a measure lighten the burden now resting so heavily on the woman of the farm.

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